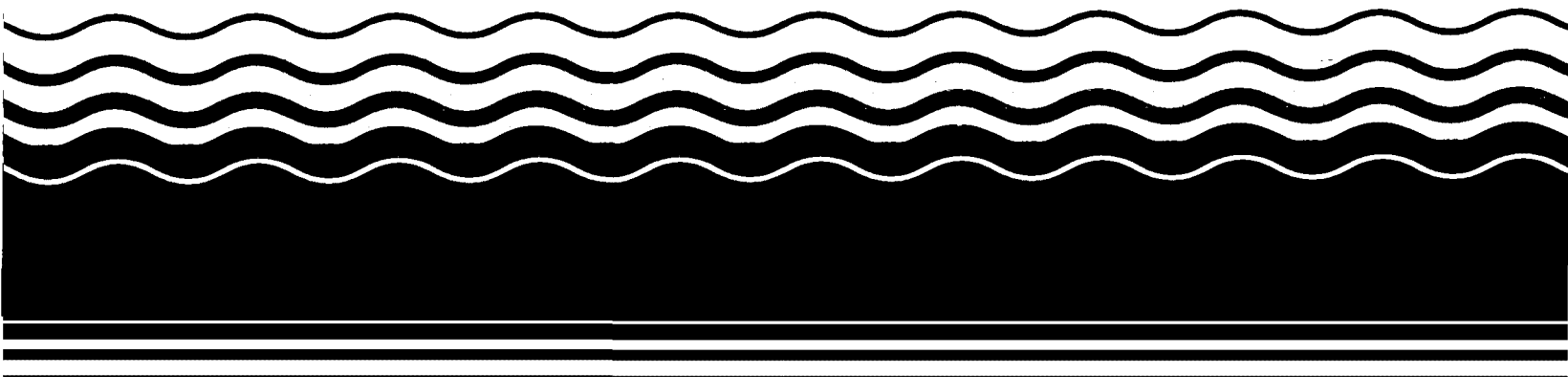




Superfund Record of Decision:

**Fort Lewis (Landfill No. 5),
WA**



NOTICE

The appendices listed in the index that are not found in this document have been removed at the request of the issuing agency. They contain material which supplement, but adds no further applicable information to the content of the document. All supplemental material is, however, contained in the administrative record for this site.

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16. Abstract (Limit: 200 words) The 180-acre Fort Lewis (Landfill No. 5) site is located on the west side of the 86,000-acre Fort Lewis Military Reservation in Pierce County, Washington. Ground water is used as the source of the municipal water supply; however, supply wells are not affected by the site. From 1967 to 1990, the landfill accepted 77,000 tons per year of mixed municipal, industrial, commercial, and residential waste and 188,000 cubic yards per year of demolition waste from the Fort Lewis Military Reservation, the VA Medical Center, and McChord Air Force Base. Dewatered sludge from the Fort Lewis Sewage Treatment Plant was also disposed onsite. Initially, waste was placed in trenches running north to south, which were covered with soil in 1971. Subsequently, until 1990, site trenches running east to west were used for disposal. In 1985, as part of the closure procedures for the inactive portions of Landfill No. 5, the Army covered the east-west trenches with a multi-layer cap. Ground water modeling conducted from 1980 to 1984 revealed that contaminant concentrations in the ground water did not exceed regulatory standards and will decrease over time because the cap will reduce leachate production. This ROD addresses a final remedy for the inactive portions of the (See Attached Page)					
17. Document Analysis a. Descriptors Record of Decision - Fort Lewis (Landfill No. 5), WA First Remedial Action - Final Contaminated Media: None Key Contaminants: None b. Identifiers/Open-Ended Terms c. COSATI Field/Group					
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EPA/ROD/R10-92/049
Fort Lewis (Landfill No. 5), WA
First Remedial Action - Final

Abstract (Continued)

landfill. Recent investigations by the Army indicate that conditions at the site currently pose no unacceptable risks to human health or the environment; therefore, there are no primary contaminants of concern affecting this site.

The selected remedial action for this site is no further action; however, onsite ground water monitoring will continue in accordance with state and local solid waste landfill operating and closure requirements. There are no costs associated with this no action remedy.

PERFORMANCE GOALS/STANDARDS: Not applicable.

RECORD OF DECISION

FORT LEWIS MILITARY RESERVATION, WASHINGTON Fort Lewis Landfill No. 5

U.S. Environmental Protection Agency, Region X

U.S. Department of the Army

Washington State Department of Ecology

July 24, 1992

RECORD OF DECISION

for the

UNITED STATES ARMY

FORT LEWIS LANDFILL NO. 5

FORT LEWIS MILITARY RESERVATION, WASHINGTON

TABLE OF CONTENTS

Declaration of the Record of Decision

Decision Summary

Page

Introduction

I.	Site Name, Location, and Description	1
II.	Site History and Enforcement Activities	2
III.	Community Relations	4
IV.	Scope and Role of Response Action Within Site Strategy	5
V.	Summary of Site Characteristics	6
VI.	Summary of Site Risks	10
VII.	Selected Remedy	19
VIII.	Documentation of Significant Changes	20
	Responsiveness Summary	21

Appendices

Appendix A: Written Comments on Proposed Plan

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Landfill No. 5

Fort Lewis Military Reservation, Pierce County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected final remedial action for Fort Lewis Landfill No. 5 in Pierce County, Washington. The selected remedy was chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for the site.

The lead agency for this decision is the U.S. Army. The U.S. Environmental Protection Agency (EPA) approves of this decision and, along with the State of Washington Department of Ecology (Ecology), has participated in the scoping of the site investigations and in the evaluation of remedial investigation data. The State of Washington concurs with the selected remedy.

DESCRIPTION OF THE SELECTED REMEDY

The Department of the Army has determined that no further remedial action is necessary at Fort Lewis Landfill No. 5 to ensure protection of human health and the environment. This decision is based on the results of the human health and ecological risk assessments, which determined that conditions at the site pose no unacceptable risks to human health or the environment. The Army will continue to implement the operating and closure requirements of Landfill No. 5 under a permit administered by the Tacoma-Pierce County Health Department. The closure complies with State Minimum Functional Standards for Solid Waste Handling, pursuant to Washington Administrative Code (WAC) 173-304, including the construction of a cover over Zones 1 through 4 of the landfill, a surface water management system to control runoff from the covered landfill, and a passive gas ventilation system to collect and burn landfill gas. As part of the closure and operation of Landfill No. 5, the Army will continue to monitor groundwater to assist in confirming the prediction of decreasing contamination. If monitoring does not confirm the prediction of decreasing contamination, the Army will evaluate the need to perform additional response action in accordance with all applicable laws and regulations. Administrative controls will be implemented to restrict future development and use of the landfill as identified under an operating or closure permit issued at the landfill.

DECLARATION

The selected remedy is protective of human health and the environment. Consistent with Section XIX of the Federal Facility Agreement, the Department of the Army will conduct a five-year review of this final remedy.

Signature sheet for the foregoing Fort Lewis Landfill No. 5 Record of Decision between the Department of the Army and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Dana a Rasmussen
Dana Rasmussen
Regional Administrator, Region X
U.S. Environmental Protection Agency

7-10-92
Date

Signature sheet for the foregoing Fort Lewis Landfill No. 5 Record of Decision between the Department of the Army and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Lewis D. Walker

Lewis D. Walker
Deputy Assistant Secretary of the Army (I, L, & E)
Environment, Safety and Occupational Health

7/24/92

Date

Carmen J. Cavezza

For Carmen J. Cavezza
Lieutenant General, U.S. Army
Commander, I Corps and Fort Lewis

20 July 1992

Date

Signature sheet for the foregoing Fort Lewis Landfill No. 5 Record of Decision between the Department of the Army and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Carol L. Fleskes

Carol Fleskes, Program Director
Toxics Cleanup Program
Washington State Department of Ecology

7/7/92

Date

Gregory A. Ackerman, A.A.G.

~~Kenneth O. Eikenberry~~
Attorney General's Office
State of Washington

July 7, 1992

Date

DECISION SUMMARY

INTRODUCTION

Fort Lewis Landfill No. 5 was listed on the National Priorities List (NPL) in 1987 under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, or Superfund), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

In accordance with Executive Order 12580 (Superfund Implementation) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Department of the Army performed a Remedial Investigation for Fort Lewis Landfill No. 5. The Remedial Investigation (RI) characterized the nature and extent of contamination in groundwater, surface water, sediments, and air near the landfill. A Baseline Risk Assessment and an Ecological Risk Assessment were conducted in 1991 to evaluate potential effects of the landfill contaminants on human health and the environment, respectively.

I. SITE NAME, LOCATION, AND DESCRIPTION

Fort Lewis Landfill No. 5 is located adjacent to the Dupont-Steilacoom Highway on the west side of the Fort Lewis Military Reservation in Pierce County, Washington (see Figures 1 and 2). It is approximately 1.5 miles north of Dupont and 3.5 miles south of Steilacoom. The western edge of the landfill is approximately 1 mile from Puget Sound. The study area of the RI included Landfill No. 5 and portions of Weyerhaeuser and Lone Star property west from the Fort Lewis boundary to Puget Sound, south to Sequelitchew Creek, and north to near Solo Point.

The Landfill No. 5 property encompasses approximately 180 acres. It is surrounded by a chain link fence, and the entrance gate at the northeast corner of the landfill is secured at the end of each work day. A 60 acre parcel within the landfill property was initially defined as Landfill No. 5 on the National Priorities List (NPL) (see Figure 3).

Landfill No. 5 is located adjacent to the northeastern portion of the City of Dupont. The predominant land use in the area is the Fort Lewis Military Reservation, which encompasses approximately 86,000 acres and forms the northeastern, east and southeastern boundaries of the City. The portion of the City west of Landfill No. 5 is now undeveloped, but the area is zoned for future industrial development. South of Landfill No. 5, the zoning changes to mixed-use, which allows a mix of office/commercial and residential uses. Land uses which might eventually be developed in this area include warehouse and office park developments, with some commercial uses concentrated near I-5 and the Dupont-Steilacoom Highway. The only proposed commercial development in the City at present is a sand and gravel mine at the Pioneer Aggregates site (see Figure 4).

Groundwater is the source of the municipal water supply for the City of Dupont. There are five active water supply wells in the City: two at Bell Hill, two at the Village of Dupont (see

Figure 2), and one at El Rancho Madrona. The Bell Hill wells are the primary water supply for the City of Dupont. These wells are intended to serve as the primary water supply for new developments in the commercial/ industrial zone west of Landfill No. 5. El Rancho Madrona, a small residential subdivision in southwestern Dupont outside of the Landfill No. 5 RI study area, is served by its own water supply well. None of these municipal water supply wells lie within or near the plume of groundwater contamination west of Landfill No. 5.

The primary source of drinking water for Fort Lewis is Sequalitchew Springs, which is located near the east end of Sequalitchew Lake approximately 4,000 feet upgradient of Landfill No. 5. Alternate source and emergency backup wells are also located upgradient of Landfill No. 5.

Surface water features are shown on Figure 5. These features include storm water drainage channels on the north, south and west sides of the landfill; Sequalitchew Lake and marshy areas to the southeast; Sequalitchew Creek and Edmond Marsh about 1/2 mile to the south and southwest; an ephemeral pond in a kettle to the west; and Puget Sound to the north and west. In addition, springs are present during the wet season along lower Sequalitchew Creek at the locations designated as 88-9-SW and 88-10-SW on Figure 5. Sequalitchew Lake and Sequalitchew Creek support populations of cold-water and warm-water fish species. Fishing activity on Sequalitchew Creek downstream of Landfill No. 5 is believed to be low because this area is private property that is not open to the public. Similarly, the lack of public access is believed to limit hunting activity in the area west of Landfill No. 5.

The Nisqually, Puyallup, and Squaxin Tribes have treaty rights to conduct commercial salmon fishing in the Nisqually Reach near Fort Lewis. Nisqually tribal fishermen use gillnets and beach seines to harvest coho and chum salmon along the Dupont shoreline between Sequalitchew Creek and Tatsolo Point. Nisqually tribal members also use the Dupont shoreline for subsistence and recreational harvesting of non-salmonid fish and shellfish.

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Fort Lewis Landfill No. 5 NPL Site Source Area operated from 1967 through July 1990. It accepted mixed municipal solid waste (industrial, commercial, and residential) and demolition waste (concrete, asphalt, wood, steel and other building debris) from the Fort Lewis Military Reservation, VA Medical Center, and McChord Air Force Base. Dewatered sludge from the Fort Lewis Solo Point Sewage Treatment Plant was also disposed at the landfill. Based on Fort Lewis records, the annual total waste stream was approximately 77,000 tons of mixed municipal solid waste and 188,000 cubic yards of demolition waste.

Initial waste placement began in a 10 to 11 acre north-south trench along the east side of the landfill (Figure 3). The north-south trench was covered with soil in about 1971. Subsequent filling of the landfill with mixed municipal and demolition waste was in east-west trenches designated Zones 1 through 4 on Figure 3. The east-west trenches covered approximately 32 acres and had a total waste thickness of 25 to 30 feet. The base of the waste was emplaced at 10 to 15 feet below the original ground surface. Along the west side of the landfill were a

series of narrow pits that were used until 1978 for sewage treatment plant floatables, bar screenings, grease trap sludges and septic system pumpings. These pits were filled and covered with low permeability material and soil.

Fort Lewis stopped using the east-west trenches in August 1990. These trenches were covered in four phases starting with the west end in 1987 and concluding on the east in November 1990. The cover was constructed to comply with State of Washington Minimum Functional Standards (MFS) for Solid Waste Handling (WAC 173-304). The cover includes a multi-layer soil and synthetic membrane system to minimize the amount of leachate produced, surface water collection and detention structures to control runoff from the covered landfill, and a passive gas ventilation system to burn methane in flare stacks.

In 1980, the Army began conducting environmental assessments at Fort Lewis under the Department of Defense Installation Restoration Program (IRP). The purpose of the program is to evaluate past and current use of toxic and hazardous materials and assess the potential for off-site migration of such materials. A limited groundwater sampling program was conducted as part of the IRP in 1980. The groundwater sampling results showed elevated iron and manganese concentrations in groundwater immediately west of Landfill No. 5. The subsequent Installation Assessment Report (1983) stated that Landfill No. 5 was the probable source of the observed iron and manganese contamination, but noted that the observed groundwater concentrations did not exceed the water quality standards then in force. Consequently, the Installation Assessment Report did not recommend further studies or remedial action at Landfill No. 5.

Additional groundwater monitoring wells were installed by the Army in 1983 and 1984 to define the configuration of the leachate plume emanating from Landfill No. 5. Groundwater sampling results indicated that elevated levels of specific conductance extended approximately 3,000 feet west of the landfill.

In 1985, the Army began preparations for closure of the inactive portions of Landfill No. 5 and development of a new cell. A Closure and Development Plan was prepared for Landfill No. 5 to ensure compliance with applicable state regulations for solid waste landfills. Groundwater sampling was conducted as part of the planning effort. Sample results again showed elevated concentrations of iron and manganese downgradient of the landfill.

As a result of the documented iron and manganese contamination of groundwater, Landfill No. 5 was added to the National Priorities List (NPL) in 1987. In 1988, the Army began a Remedial Investigation (RI) to characterize the nature and extent of contamination and to assess potential risks to human health and the environment.

A. Source Areas

Groundwater sampling conducted for the Closure and Development Plan (1985) indicated that the east-west trenches (Zones 1-4) and the north-south trench of Landfill No. 5 were the predominant sources of most of the compounds detected in groundwater samples (Figure 3). The septic/sewage sludge pits along the west side of the landfill also were identified as potential

sources of groundwater contamination. Computer simulations indicated that leaching of landfill wastes was the primary mechanism for contaminant transport to groundwater.

B. Enforcement

Under the authority of the Tacoma-Pierce County Health Department, Landfill No. 5 Zones 1 through 4 were closed in compliance with Washington State Minimum Functional Standards for Solid Waste Handling (Washington Administrative Code (WAC) 173-304).

On January 29, 1990, the Army, the EPA, and the State of Washington Department of Ecology (Ecology) entered into a Federal Facility Interagency Agreement (IAG). The IAG established a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions conducted at Fort Lewis. Under the terms of the IAG, EPA and Ecology provided oversight of subsequent RI activities and agree on the final remedy for this Record of Decision (ROD).

III. COMMUNITY RELATIONS

A. Community Relations During the RI

The Army developed a community relations plan (CRP) in 1988 as part of the overall management plan for the Fort Lewis Landfill No. 5 RI/FS. The community relations plan was designed to promote public awareness of the investigations and public involvement in the decision-making process.

Before the CRP was prepared, local citizens and public officials were interviewed to identify potential issues and concerns associated with Landfill No. 5. This information was used to tailor the CRP to meet the specific needs of the local communities.

Several news releases and fact sheets were prepared and distributed for public review. The news releases and fact sheets provided summaries of RI/FS work in progress, results to date, and upcoming activities. These are listed as follows:

Document	Date
News Release #1	11/89
Fact Sheet #1	1/89
EPA News Release	1/90
EPA Fact Sheet	1/90
Seattle Post-Intelligencer Article	1/90
Seattle Times article	1/90
News Release #2	2/92
Fact Sheet #2	2/92
Proposed Plan	2/92

To promote community awareness of RI/FS activities, information repositories containing primary site documents were established at the following three locations:

Tillicum Library
14916 Washington Ave. SW
Tacoma, WA 98498
(206) 588-1014

Lakewood Library
6300 Wildaire Road
Tacoma, WA 98499
(206) 582-6040

Fort Lewis Environmental and Natural Resources Division
Fort Lewis, WA 98433-5000
(206) 967-5337

Also, in accordance with section 113 of CERCLA, an administrative record was established to provide the basis for the selected remedy. The administrative record is available for public review at the Lakewood Library and the Fort Lewis Environmental and Natural Resources Division.

B. Community Relations to Support Selection of Remedy

The public was given the opportunity to participate in the remedy selection process, in accordance with Sections 113 (k)(2)(B)(i-v) and 117 of CERCLA. The Proposed Plan, which summarized the RI results and described the preferred alternative, was mailed to approximately 300 interested parties on February 6, 1992. The Army provided public notice through an advertisement in the *Tacoma Morning News Tribune* to explain the Proposed Plan, list the public comment period, and announce the public meeting. A news release was provided to local media on February 26, 1992, which resulted in news coverage by the *Tacoma Morning News Tribune* on February 28, 1992.

A 30-day public comment period was held from February 6 to March 9, 1992. No requests for extension were received. Approximately 34 people attended a public meeting held in the Dupont City Hall/Community Center on March 3, 1992. Oral and written comments were considered by EPA, the Army, and Ecology in selecting the no further action alternative.

One set of written comments, post-marked March 10, 1992, were received. Responses to these comments are included within the Responsiveness Summary.

IV. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

In keeping with standard environmental management of municipal landfills, closure of the Landfill No. 5 was initiated in 1987 before its listing on the National Priorities List and was

conducted under the authority of the Tacoma-Pierce County Health Department. The closure complies with State Minimum Functional Standards for Solid Waste Handling (Washington Administrative Code (WAC) 173-304) and included the construction of a cover over Zones 1 through 4 of the landfill, a surface water management system to control runoff from the covered landfill, and a passive gas ventilation system to collect and burn landfill gas. In accordance with WAC 173-304, the Army will continue to perform operations, maintenance, and monitoring of the landfill systems with oversight provided by the Tacoma-Pierce County Health Department.

The Fort Lewis Landfill No. 5 RI evaluated the nature and extent of contamination in all potentially affected media including groundwater, surface water, soil, sediment, and air. Based on the results of the RI, the Baseline Risk Assessment, and the Ecological Risk Assessment, no further remedial action under CERCLA is necessary to ensure protection of human health or the environment.

V. SUMMARY OF SITE CHARACTERISTICS

A. Site Geology & Hydrogeology

Fort Lewis Landfill No. 5 is situated on a glacial outwash plain that slopes gently to the west toward Puget Sound. The elevation of the plain in the vicinity of the landfill is 200 to 220 feet above mean sea level (MSL). Major features of relief in the study area are the Burke Hills to the north, the canyon cut by Sequatchew Creek to the south, several kettles (glacial-derived depressions) between the landfill and Puget Sound, and the steep cliff face separating the outwash plain from the narrow beach along Puget Sound.

Landfill No. 5 is underlain by a series of glacial and interglacial deposits (see Figures 6 and 7). The uppermost formation, the Vashon Drift, is approximately 75 feet thick. It consists of gravels, glacial till, and sand, and contains significant quantities of groundwater. Beneath the Vashon Drift is the Kitsap Formation, which consists of about 70 feet of fine sands and silty clays with small lenses of organic material. The Salmon Springs Formation underlies the Kitsap Formation. The Salmon Springs Formation consists of about 50 feet of glacial sand and gravel deposits which contain appreciable groundwater. Beneath the Salmon Springs Formation is the Puyallup Formation, which consists of fine-grained silt and clay with occasional deposits of fine sand and gravel.

Approximately 3,000 feet west of Landfill No. 5, the Vashon Drift, Kitsap, and Salmon Springs Formations are replaced by the Sequatchew Delta deposit. The Sequatchew Delta formation consists of at least 220 feet of coarse-grained glacial outwash material. It contains significant amounts of groundwater.

Two distinct groundwater flow systems have been identified in the local study area; a shallow unconfined flow system in the Vashon Drift Aquifer and a deeper confined flow system in the Salmon Springs Aquifer (see Figure 8). Aquifers deeper than the Salmon Springs Aquifer are not believed to have been affected by landfill activities. The Vashon Drift and Salmon Springs flow systems are interconnected due to leakage from the shallow system downward

through the less permeable Kitsap Aquitard. Estimated groundwater travel time through the Kitsap Aquitard is about 6 years. Groundwater in the shallow Vashon Drift Aquifer flows west and northwest at a rate of approximately 18 - 330 feet/year. Groundwater in the underlying Salmon Springs Aquifer flows toward the northwest at a rate of approximately 0.5 to 1300 feet/year.

The Vashon Drift and Salmon Springs Aquifers are replaced by the Sequelitchew Delta Aquifer about 3,000 feet west of the landfill (see Figure 8). The water table within the Sequelitchew Delta Aquifer is at about 10 feet above mean sea level (MSL), which is much deeper than the water table in the Vashon Drift Aquifer (approximately 185 feet MSL). Groundwater in the Sequelitchew Delta aquifer flows toward Puget Sound at a rate of approximately 4,000 to 37,000 feet/year.

Recharge to the water table flow system in the study area comes primarily from precipitation and lateral flow within the Vashon Drift Aquifer. Upon entering the water table aquifer, groundwater flows to the west and northwest, while a small amount moves vertically downward through the Kitsap Aquitard. At the edge of the Vashon Drift unit, the groundwater flows downward to the water table in the Sequelitchew Delta Aquifer, at a velocity of about 3 to 5 feet/day. Estimated travel time from the vicinity of the landfill through the water table aquifers to discharge as springs along Puget Sound is in the range of 25 to 100 years.

Recharge to the confined aquifer flow system in the study area comes primarily from vertical migration through the Vashon Drift Aquifer and leakage through the Kitsap Formation or lateral flow within the Salmon Springs Aquifer. Upon entering the confined aquifer, groundwater flows to the west and northwest. A small, but unquantified amount may move vertically downward through the Puyallup Aquitard. At the edge of the Salmon Springs Formation, the groundwater flows downward to the water table in the Sequelitchew Delta Aquifer, under a gradient estimated as 0.05 and a velocity of about 7 to 18 feet/day. Using the hydraulic parameters estimated in the RI, the travel time from the vicinity of the landfill vertically through the Vashon Drift Aquifer and Kitsap Aquitard, then laterally to discharge as tidal or subtidal springs along Puget Sound is in the range of six to seventy-five years.

B. Nature and Extent of Contamination

1. Groundwater

For the RI, groundwater samples were collected from 25 monitoring wells on four occasions between February 1989 and January 1990. Two additional wells were installed in January 1990 and sampled in January and May 1990. RI well locations are shown in Figure 9. Groundwater samples were analyzed for a broad range of chemical and physical parameters. Tables 1 through 4 summarize the analytical results for groundwater samples collected during the RI.

Water samples were collected from the Vashon Drift, Salmon Springs and Sequelitchew Delta Aquifers to evaluate the presence of landfill-derived contaminants in groundwater. At the time of sample collection, the temperature, pH, Eh and specific conductance of the water were

measured. In general, pH and specific conductance show spatial trends that could be considered indicative of contamination from the landfill. Laboratory analysis of the water samples provided data on the presence of inorganic and organic contaminants in the groundwater. Of the inorganic compounds measured, only iron, manganese, chloride and, perhaps, barium appear to be related to the landfill. Several volatile organic compounds (vinyl chloride; chloroethane; 1,1-DCA; 1,2-DCE; 1,2-DCA; TCE; PCE; 1,1,2,2-PCA; benzene; toluene; ethylbenzene and xylenes) and base/neutral and acid-extractable (BNA) organic compounds (naphthalene; diethylphthalate, bis(2-ethylhexyl)phthalate; 4-methyl phenol; 1,4-dichlorobenzene; acenaphthene and di-n-octyl phthalate) were detected in monitoring wells primarily near the downgradient edge of the landfill. Neither organochlorine pesticides nor PCBs were detected in any of the water samples. A summary of groundwater contamination in each of the aquifers follows.

The Vashon Drift Aquifer immediately underlies the landfill and shows the highest levels and extent of contamination. The specific conductance, manganese and chloride levels in groundwater are elevated relative to background as much as 3,000 feet downgradient of the landfill. Near the landfill, the groundwater pH appears to be slightly lower than the background values, and iron and manganese are 3 to 4 orders of magnitude higher than background. Elevated manganese concentrations extend farther downgradient than the high iron values. The barium concentration is elevated near the landfill in the Vashon Drift Aquifer; however, none of the other trace inorganic compounds (arsenic, cadmium, chromium, lead, mercury, selenium, silver and zinc) evaluated in this study were detected at a level or with a pattern of occurrence that suggest that the landfill is the source of these compounds in the groundwater.

The only wells that showed moderately consistent detections of volatile organic compounds (VOCs) in water samples from the Vashon Drift Aquifer were those nearest the landfill. The maximum concentration of any of these compounds detected is 16 micrograms per liter ($\mu\text{g/L}$). The VOCs with the greatest areal distribution are 1,1-DCA and 1,2-DCE. Because VOCs were not analyzed in water samples collected from some of the wells completed in the Vashon Drift Aquifer, the westerly extent of contamination of 1,1-DCA and 1,2-DCE is uncertain. As with the VOCs, the majority of the BNA compounds detected were found in the cluster of wells adjacent to the western (downgradient) edge of the landfill. Diethylphthalate is the only BNA compound that appears to be present beyond the margin of the landfill, but its distribution is limited.

The Salmon Springs Aquifer occurs beneath the Vashon Drift Aquifer, and the two aquifers are separated by the Kitsap Formation Aquitard. The affected area in the Salmon Springs Aquifer, as shown by elevated specific conductance of the groundwater, is limited to approximately 1,000 to 2,500 feet from the landfill. At monitoring well 88-5-SS nearest the landfill in this aquifer, the specific conductance and chloride concentrations of water samples are elevated and the pH is slightly depressed, as was the case with samples from the overlying Vashon Drift Aquifer. In addition, barium, iron and manganese concentrations in groundwater collected from the Salmon Springs Aquifer are elevated in the zone near the landfill.

Water samples from monitoring well 88-5-SS contained the VOC compounds vinyl chloride, chloroethane, 1,1-DCA, 1,2-DCE, TCE, 1,1,2,2-TCA, benzene, toluene and xylenes. These compounds were also found in water from the overlying Vashon Drift Aquifer and probably represent landfill contamination. The wells in the Salmon Springs Aquifer adjacent to 88-5-SS did not contain detectable quantities of any of these compounds, therefore the VOC plume in the Salmon Springs Aquifer is much more restricted than that in the Vashon Drift Aquifer. Water samples from monitoring well 88-5-SS contained naphthalene and diethylphthalate, but they were not detected in any other Salmon Springs Aquifer monitoring wells.

The Sequatchew Delta Aquifer is the water table aquifer that is present between the western edge of the Vashon Drift/Salmon Springs Aquifers and Puget Sound. The primary inorganic parameters that have been identified as indicators of the presence of contamination in groundwater at this site (specific conductance, iron and manganese levels) were not found to be elevated in groundwater samples collected from the Sequatchew Delta Aquifer. Three VOCs (1,1,2,2-PCA; 1,1,2-trichloro 1,2,2-trifluoroethane; and toluene) were found at low concentrations and in random patterns in a few water samples. These compounds were not consistently detected, and the few detections were assumed to be sampling or analysis artifacts. There were no confirmed detections of any BNA compounds in water samples collected from any of the Sequatchew Delta Aquifer monitoring wells.

To assess contaminant fate and transport, the results of the RI groundwater sampling program were incorporated in the U.S. EPA's Multi-Media Model. The model estimated that contaminant concentrations would decrease over time because the multi-layer cap installed at Landfill No. 5 during 1987-1990 would reduce leachate production. Figures 10 through 14 show the model-calculated trends in concentrations of several key contaminants.

Supplemental groundwater sampling was conducted after completion of the RI. Six monitoring wells were sampled in April, June, and September 1991 to monitor spatial and temporal trends in the contamination plume. As shown in Figure 15, generally contaminant concentrations of most contaminants are decreasing with time, which is consistent with the results of the RI contaminant transport model.

2. Surface Water Contamination

The surface water quality sampling program included the following water quality parameters: field measurements (temperature, specific conductance, pH and Eh), organic compounds (VOCs, BNAs, pesticides/PCBs), inorganic compounds (primarily metals), and conventional water quality parameters. Surface water sampling locations are shown in Figure 5. Sampling results are summarized in Table 5.

In general, the chemical data indicate that the landfill is not affecting surface water quality at the site. Very few organic compounds were measured in any of the surface water samples. Of the twelve metals analyzed (Ag, As, Ba, Cd, Cr, Fe, Hg, Mn, Na, Pb, Se and Zn), five (Ag, As, Cr, Pb and Se) were not measured above their detection limits and of the remainder all, except for Na, had low concentrations or levels similar to background. The sodium concentration in water collected from the beach seep was high compared to groundwater and other surface water values, but this is due to the impact of seawater on the beach seep. None

of the conventional water quality parameters show values that would indicate the presence of contamination from the landfill.

3. Sediment Contamination

Sediment samples were collected from the surface water monitoring stations and an infiltration basin on the landfill. A few VOCs, BNAs and several inorganic constituents were detected (see Table 6). Most of the inorganic compounds were found at sampling stations upstream as well as downstream of the landfill; therefore, it was determined that Landfill No. 5 is not a source of sediment contamination. The Army is studying past and current waste disposal practices in the vicinity of the drainage channel under a separate investigation to determine the likely source of sediment contamination.

4. Air Contamination

Landfill gases emitted from Landfill No. 5 are collected by a network of perforated underground pipes and directed to 10 flare stacks for burning. Gas emissions are too low to keep the flare stacks burning continuously. Therefore, the flare stacks often act as vents.

Landfill gas emissions were sampled at 3 of the 10 flare stacks on the landfill. Several VOCs, including toluene, benzene, vinyl chloride, and methylene chloride, were detected (see Table 7). To estimate impacts on ambient air quality, the landfill gas sampling results were incorporated in U.S. EPA's Industrial Source Complex-Long Term computer model. This model provides conservative results, typically predicting ambient concentrations that are two to three times higher than actual measured concentrations. The maximum predicted VOC concentrations are several orders of magnitude lower than the stack concentrations and are well below the Puget Sound Air Pollution Control Agency's Acceptable Source Impact Levels.

VI. SUMMARY OF SITE RISKS

The baseline risk assessment for Fort Lewis Landfill No. 5 considered human health and ecological risks. The risk assessments were conducted in accordance with EPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* and *Volume II: Environmental Assessment Manual* and EPA national guidance. The risk assessment methods and results are summarized in the following sections.

A. Human Health Risks

The human health risk assessment evaluated potential risks associated with exposure to chemical contaminants from Landfill No. 5. The assessment considered potential exposure to landfill contaminants in groundwater, surface water, sediment, and air. Soil was not included in the quantitative risk assessment because the landfill cap precludes direct exposure to underlying contaminated soil. Both carcinogenic (i.e., causing the development of cancer) and non-carcinogenic (i.e., direct toxic effects on organ systems, reproductive and developmental effects) risks were evaluated. Risks were estimated for current and future land uses in the vicinity of Landfill No. 5. The assessment estimated hypothetical risks for people

residing or working adjacent to the west edge of the landfill and at the edge of the contaminated groundwater plume approximately 3,000 feet west of the landfill. The risks are hypothetical because no one resides or works in these areas at this time. Risks also were estimated for workers at the landfill and trespassers adjacent to the landfill.

To ensure that potential health risks would not be underestimated, a conservative approach was used as recommended in EPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* and EPA national guidance. Reasonable conservative estimates and assumptions were used to enhance confidence in the conclusions of the risk assessment. Key steps in the risk assessment are outlined below.

1. Identification of Chemicals of Concern

Potential chemicals of concern are those that are released to the environment from waste sources at Landfill No. 5 and that may pose health risks to humans who come into contact with them. In the Landfill No. 5 risk assessment, chemicals of concern were identified through evaluation of RI sampling results for groundwater, surface water, sediments, and landfill gas emissions. Groundwater was sampled at more than 22 monitoring wells on a quarterly basis over a 15-month period. Surface water and sediments in nearby waterways were also sampled quarterly. Landfill gas emissions were sampled once at three locations.

All chemical analytes for the sampled media were included in the risk assessment except the following: (1) chemicals that were not detected in groundwater, surface water, sediment, or landfill gas; (2) chemicals for which toxicity reference values, such as cancer slope values or reference doses (RfDs) have not been developed; and (3) chemicals identified as essential nutrients. In addition, compounds determined to be unrelated to the landfill source were excluded from the risk assessment. Tables 1, 2, 3, 4, and 6 list the potential chemicals of concern included in the risk assessment for Landfill No. 5.

All compounds detected in landfill gas emissions were identified as chemicals of concern and included in the quantitative risk assessment. No site-related chemicals of concern were found in surface waters and springs, and RI hydrologic data showed that surface waters and springs were unlikely to be affected in the future. Consequently, surface water was not evaluated in the quantitative risk assessment.

Potential chemicals of concern in groundwater and sediments were subjected to a risk-based screening process in order to identify chemicals to be included in the quantitative risk assessment. The maximum detected concentration of each potential chemical of concern was compared to risk-based and regulation-based screening concentrations. For groundwater, the risk-based screening concentrations were those that would result in an estimated incremental lifetime cancer risk greater than 1×10^{-6} (1 in 1,000,000) or a hazard quotient greater than 0.1. For sediments, the risk-based screening concentrations were those that would result in an estimated incremental lifetime cancer risk greater than 1×10^{-7} (1 in 10,000,000) or a hazard quotient greater than 0.1. Chemicals which exceeded the risk-based screening concentrations were included in the quantitative risk assessment. Table 8 lists the chemicals of concern that passed the screen and were evaluated in the quantitative risk assessment.

2. Exposure Assessment

a. Exposed Populations

Exposure pathways were evaluated for the following receptors:

Current Use:

- Worker at Landfill No. 5
- Trespasser visiting the drainage channel adjacent to the landfill

Future Use:

- Future resident living adjacent to the western edge of the landfill
- Future resident living at the edge of the groundwater plume, approximately 3,000 feet west of the landfill
- Worker at a future industrial site adjacent to the western edge of the landfill for 30 years
- Worker at a future industrial site at the edge of the groundwater plume, approximately 3,000 feet west of the landfill

b. Exposure Pathways

The following exposure pathways were evaluated:

- Ingestion of groundwater by hypothetical future residents and industrial workers
- Inhalation of landfill gas emissions by hypothetical future residents and industrial workers and current landfill workers
- Inhalation of VOCs released from groundwater during domestic use by hypothetical future residents
- Dermal absorption of organic compounds in groundwater by hypothetical future residents during showering
- Ingestion of sediments by regular visitors to the drainage channel
- Dermal absorption of organic compounds in sediments by hypothetical visitors to the drainage channel

c. Exposure Point Concentrations

Groundwater: Average and reasonable maximum exposure concentrations were estimated based on transport and dispersion modeling and/or field measurements. Groundwater transport modeling was used to estimate concentrations of chemicals of concern at potential exposure points over 10- and 30-year periods. Average estimated groundwater exposure concentrations are listed in Table 9. These are considered reasonable maximum concentrations for the following reasons:

- Estimated future chemical concentrations at the well closest to the landfill source, well LS-Ax-VD, were used as potential exposure point concentrations for the residential scenario. Well LS-Ax-VD had the highest chemical concentrations measured in groundwater during the RI. Groundwater sample results from this well were used to back-calculate the landfill source concentrations used in the contaminant transport model.
- Concentrations at well 89-17-VD were used to represent potential exposure point concentrations for the Sequimitchew Delta Aquifer, which is the likely source of groundwater for the future industrial development scenario. Well 89-17-VD is located in the Vashon Drift Aquifer at the leading edge of the plume, approximately 3,000 feet west of Landfill No. 5. Chemical concentrations found in the Sequimitchew Delta Aquifer were significantly lower than those found in the Vashon Drift Aquifer.
- Concentrations decrease with time because of declining concentrations within the landfill and reduced leachate production because of the landfill cover. As noted in Figure 15, groundwater sampling conducted after the RI was completed appears to validate the model-calculated decline in contaminant concentrations.

Air: Air dispersion modeling of flare vent stack emissions was performed to identify the points of maximum impact of landfill gas emissions both onsite and offsite. The ISCMT model used for this assessment typically predicts chemical concentrations that are two or three times higher than actual concentrations in ambient air. A conservative estimate of landfill gas flow rates was used to further reduce the chance of under-predicting ambient air concentrations. Estimated exposure point concentrations are listed in Table 10.

Average sediment exposure concentrations were estimated by taking the average concentrations of the chemicals of concern measured at the two sampling locations downstream of Landfill No. 5. The highest concentration of each chemical was used as the maximum exposure concentration. For comparison purposes, average and maximum exposure concentrations also were calculated for the two sampling stations located upstream of the landfill. The average and maximum concentrations at the two sediment exposure points are listed in Table 11.

d. Chemical Intake by Exposure Pathway

Chemical intakes for each exposure pathway were calculated based on the exposure point concentrations and other exposure parameters such as water and sediment ingestion rates,

inhalation rates, dermal absorption rates, body weights, exposure frequencies and durations. Reasonable maximum exposure calculations for the Fort Lewis Landfill No. 5 risk assessment used values from the Standard Default Exposure Factors document (OSWER Directive No. 9285.6-03).

3. Toxicity Assessment

The toxicity assessment addresses the potential for a chemical of concern to cause adverse effects in exposed populations and estimates the relationship between extent of exposure and extent of toxic injury (i.e., dose-response relationship). Qualitative and quantitative toxicity information for the chemicals of concern is acquired through evaluation of relevant scientific literature. The most directly relevant data come from studies in humans. Most of the useable information on the toxic effects of chemicals comes from controlled experiments in animals. Table 12 lists the toxicity values for the chemicals of concern.

Slope factors (SFs) have been developed by EPA for estimating excess lifetime cancer risks associated with exposure to potential carcinogens. SFs, which are expressed in units of $(\text{mg/kg-day})^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day , to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the SF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Slope factors are derived from the results of human epidemiological studies or chronic animal bioassays to which mathematical extrapolation from high doses to low dose has been applied (e.g., to account for the use of animal data to predict effects on humans).

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day , are estimates of lifetime daily exposure levels for humans, including sensitive individuals which are likely to be without risk of adverse effect. Estimated intakes of contaminant(s) of concern from environmental media (e.g., the amount of a contaminant(s) of concern ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans).

4. Risk Characterization

Carcinogenic risk is estimated as the incremental probability of an individual developing cancer above the normal background population incidence over a lifetime of potential exposure to a chemical known or suspected to cause cancer. To estimate cancer risk, slope factors are combined with site exposure information to estimate the incremental cancer risk; i.e., the increase in the probability of contracting cancer. An excess lifetime cancer risk of 1×10^{-4} indicates that an individual has up to a one in ten thousand chance of developing cancer over a lifetime of exposure to a site-related carcinogen.

Table 13 lists the estimated health risks for each receptor and pathway. The total excess cancer risk for reasonable maximum residential exposures to groundwater and landfill gas at the landfill boundary is 1.4×10^{-5} (approximately 1 in 100,000). This risk level is within the EPA Superfund acceptable risk range of 1×10^{-4} to 1×10^{-6} (1 in 10,000 to 1 in 1,000,000). All other exposure scenarios (residential on plume axis and industrial at boundary and at plume axis) resulted in lower cancer risks. Noncarcinogenic health hazards are not expected from exposures resulting from Landfill No. 5. Only one exposure pathway resulted in a hazard index near 1 (reasonable maximum ingestion of groundwater by a hypothetical resident located at the landfill fenceline).

The chief contributors to the estimated cancer risk are ingestion of vinyl chloride in groundwater and inhalation of vinyl chloride and 1,1,2,2-PCA released from groundwater during domestic use. The cancer risks may be overestimated because, although the maximum detected concentration of 1,1,2,2-PCA exceeded the screening level, the chemical analytical results suggest that its actual presence in groundwater is questionable. Nevertheless, including it in the risk assessment is a conservative approach that will result in risk estimates that are unlikely to be exceeded under actual exposure conditions.

The sediment exposure scenario is a special case that was included to assess potential health threats that may be associated with exposure to compounds in sediments in the drainage channel adjacent to the landfill. The landfill has not been identified as a source of the compounds detected in the sediments because the channel drains a large area upstream and the same compounds are detected both upstream and adjacent to the landfill. Ingestion of channel sediments under a trespasser exposure scenario results in an estimated excess cancer risk of 6×10^{-6} , due entirely to the presence of arsenic, a common constituent of herbicides that may have had widespread use in the area.

Human Health Risk Characterization Summary

The results of the baseline human health risk assessment support the following conclusions concerning the potential health hazards associated with exposures to groundwater, landfill gas emissions, and sediments in the drainage channel:

- The total excess cancer risk for reasonable maximum residential exposures to groundwater and landfill gas at the property fenceline is 1.4×10^{-5} (approximately 1 in 100,000). This risk level is within the EPA Superfund acceptable risk range of 1×10^{-4} to 1×10^{-6} (1 in 10,000 to 1 in 1,000,000). The exposure assumptions are extremely conservative, and it is unlikely that the estimated risk level would be exceeded under any likely exposure conditions.
- The chief contributors to the estimated cancer risks are ingestion of vinyl chloride in groundwater and, in the residential scenarios, inhalation of vinyl chloride and 1,1,2,2-PCA released from groundwater into indoor air. Because 1,1,2,2-PCA was detected only twice in 50 samples, inclusion of this compound in the risk assessment is a conservative approach that may result in overestimation of cancer risk.

- Reasonable Maximum Exposure (RME) excess cancer risks for hypothetical industrial receptors at the downgradient well 89-17-VD and at the fenceline are 1×10^{-6} and 2×10^{-6} , respectively. The assumed exposure conditions are very conservative, and it is unlikely that these risk levels would be exceeded under any likely exposure conditions.
- Noncarcinogenic health hazards are not expected from exposures to groundwater or landfill gas. Only one exposure pathway resulted in a hazard index near 1.0 (reasonable maximum ingestion of manganese-contaminated groundwater by a hypothetical resident located at the landfill fenceline). However, this exposure scenario is unlikely to occur because the area west of the landfill is uninhabited, the area is zoned for industrial development, and future residential development is planned for locations distant from the landfill and away from the plume of contaminated groundwater.
- No health threats are posed to current landfill workers by inhalation of landfill gas emissions.
- Incremental cancer risk due to RME exposures to sediments in the drainage channel range are approximately 1 in 1,000,000 (1×10^{-6} upgradient of landfill and 6×10^{-6} adjacent to the landfill). The landfill has not been identified as a source of the compounds in the channel sediments, and therefore the health risks may or may not be landfill-derived. The incremental cancer risk is almost entirely attributable to ingestion of arsenic in the sediments.
- The results of the risk assessment indicate that exposure to chemicals of concern in groundwater and air near the landfill is not likely to result in a public health hazard.

5. Uncertainty

The primary sources of uncertainty for this risk assessment are associated with the estimates of exposure point concentrations and the assumptions regarding human exposure scenarios. Conservative assumptions were used so that risks would not be underestimated. Chemicals of concern were selected using a health-risk-based screen and included all compounds present in concentrations that might pose potential health risks. The groundwater transport and air dispersion models estimate exposure point concentrations that are not likely to be exceeded and, as a result, may overstate the concentrations to which individuals may be exposed. A reasonable worst-case exposure scenario at the landfill fenceline was addressed. The ingestion rates, inhalation rates, and exposure times used in estimating daily intakes are conservatively high and, as such, are not likely to be exceeded. Toxicity factors used to assess potential health risks are derived from studies in sensitive animal species and the application of safety factors and conservative relationships between dose and response.

The results of the risk assessment provide an upper-bound estimate of potential risk under reasonable worst-case exposure conditions. The results indicate that exposures to groundwater, air, and sediments near the landfill are not likely to have adverse effects on public health.

B. Ecological Risk Assessment

An ecological risk assessment was conducted to evaluate the potential impacts on biota of chemical constituents in groundwater, surface water, or sediment that may have been released from Fort Lewis Landfill No. 5. The primary objective of the ecological risk assessment was to perform a screening-level analysis to estimate the potential for adverse effects to plants and animals that may result from exposures to hazardous compounds. The results of the ecological risk assessment were intended to support management decisions on whether remedial action is required for environmental protection.

The approach used in the risk assessment is consistent with EPA guidance for evaluating ecological risk. The basic steps were identification of chemicals of concern, assessment of potential exposure pathways, and characterization of threats to exposed biota. These steps are summarized below.

1. Identification of Chemicals of Concern

Groundwater, surface water and sediment were sampled and analyzed for a wide variety of potentially hazardous volatile organic compounds (VOCs), base/neutral and acid-extractable organic compounds (BNAs), pesticides/PCBs and inorganic compounds. PCBs were not detected in any of the media, and 4,4-DDD was the only pesticide detected (in sediment only) in any media downgradient of the landfill. Several VOCs, BNAs and inorganic compounds were detected in water and sediment. These compounds were identified as chemicals of concern for further evaluation in the risk assessment.

2. Exposure Assessment

a. Exposed Populations

Potential receptors were identified as those plant and animal species likely to be exposed to chemicals in surface water or sediments. The assessment focused on the ingestion and dermal absorption exposure routes because these are the most likely routes for exposure to chemicals in sediment or water. The risk assessment directly assessed potential threats to freshwater aquatic organisms, vegetation, marine organisms and terrestrial organisms. No sensitive resident species or habitats were identified in areas that might be affected by the groundwater plume.

b. Exposure Pathways

The exposure assessment identified potential exposure pathways from the chemical source to the affected media, exposure points and potential receptors. Groundwater, surface water and sediments in the surface water bodies were identified as the affected media, based on RI data. The primary exposure points were determined to be surface water bodies (creeks, lakes, drainage channels) in the vicinity of the landfill. Landfill gas emissions were considered an unlikely source of ecological risk because of the amount of dilution of the gas on mixing with air. Groundwater also was considered an unlikely exposure medium because the water table is normally twenty feet or more below land surface; consequently, ecological receptors cannot

come into direct contact with it. Exposure could occur only where groundwater discharges to surface water bodies. Most of the surface water bodies located near Landfill No. 5 do not intersect a contaminant transport pathway from the landfill. The RI demonstrated that Sequalitchew Lake, Harner Marsh, McKay Marsh, Edmond Marsh, Sequalitchew Creek and the springs along Sequalitchew Creek are not hydraulically downgradient of the landfill; consequently, these water bodies are not affected by the groundwater plume emanating from the landfill.

Potential surface water exposure points downgradient of the landfill include the drainage channel adjacent to the landfill, a kettle lake, beach seeps, and Puget Sound. Sediments in the drainage channel and kettle lake were also considered potential exposure media. Groundwater is the primary transport mechanism from the landfill to the beach seeps and Puget Sound. The natural processes of dispersion and mixing are expected to dilute groundwater concentrations to less than detectable levels during transport to discharge locations along the Sound. Therefore, the beach seeps and Puget Sound are not believed to be significant ecological exposure points.

3. Risk Characterization

The potential for ecological threats associated with exposure to surface water and sediments in the drainage channel and kettle were assessed by comparing the maximum concentration ranges to normal environmental concentrations and to toxicity-based benchmarks. In the drainage channel, bis(2-ethylhexyl)phthalate was the only compound detected in water whose maximum concentration equalled or exceeded ambient water quality criteria. Maximum concentrations of 4-methylphenol, pentachlorophenol and 4,4-DDD in drainage channel sediments exceeded toxicity benchmark levels; however, it is unlikely that the covered landfill could be a current source of these compounds because refuse is not exposed and the water table does not appear to intersect the base of the drainage channel.

Concentrations of several inorganic compounds (arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel and zinc) were higher in drainage channel sediments than would be expected for normal environmental conditions. The second screening of these inorganics showed that arsenic and lead concentrations exceeded toxicity-based benchmarks. Mercury and copper had values below toxicity-based benchmarks, but above benchmarks that account for the strong bioconcentration potential of these metals. Bioconcentration occurs when a chemical is taken in at a faster rate than it can be metabolized or excreted, which results in concentrations in organisms that are higher than concentrations in the organism's surroundings. Thus, even low environmental concentrations of a chemical with strong bioconcentration potential can result in deleterious concentrations in organisms.

The source(s) of the organic and inorganic potentially toxic compounds in the drainage channel sediments have not been identified. The drainage channel collects storm water runoff from a large portion of the Fort Lewis Military Reservation and the Village of Dupont which are located upgradient of the landfill. Consequently there are many possible sources for these compounds other than the landfill.

Sediments sampled from the kettle contained levels of cadmium, lead, mercury, copper and arsenic that were higher than normal environmental concentrations. Lead was the only inorganic detected above single-species toxicity-based benchmarks. Mercury had concentrations above values that account for bioconcentration. Exposures to lead and mercury may pose ecological hazards to biota inhabiting the kettle. However, the hazards are not likely to be landfill-related because these inorganic compounds were not detected in groundwater (the only significant chemical transport mechanism to this exposure point). Possible sources are unauthorized refuse dumping and the use of arsenical herbicides. Concentrations of inorganic compounds tested in kettle surface water samples were all below toxicity benchmarks.

The approach taken in the ecological risk assessment was conservative. Maximum detected concentrations of chemicals were compared to benchmarks values. When ambient water quality or sediment standards were not available for a given chemical, appropriate safety factors were used to develop toxicity-based benchmarks. Normal environmental ranges of chemicals in soils of the Western United States were also used as a screening tool to compare to measured maximum concentrations in sediment. The threat to biota from normal concentration ranges of compounds was not assessed.

Few compounds had maximum concentrations that exceeded benchmarks. Generally, the benchmarks were exceeded in only a single sample. It is unlikely that these compounds are now being released from the landfill because the refuse is not exposed to surface runoff and leachate-affected groundwater either does not contain the compounds or does not discharge into the surface water bodies in question. Furthermore, there are non-landfill sources for these compounds. The results of this ecological risk assessment indicate that there is little evidence that Landfill No. 5 poses any threat to ecological receptors or habitats.

VII. THE SELECTED REMEDY

The Department of the Army has determined that no further remedial action is necessary at Fort Lewis Landfill No. 5 to ensure protection of human health and the environment. This decision is based on the results of the human health and ecological risk assessments, which determined that conditions at the site pose no unacceptable risks to human health or the environment. The Army will continue to implement the operating and closure requirements of Landfill No. 5 under a permit administered by the Tacoma-Pierce County Health Department. The closure complies with State Minimum Functional Standards for Solid Waste Handling, pursuant to Washington Administrative Code (WAC) 173-304, including the construction of a cover over Zones 1 through 4 of the landfill, a surface water management system to control runoff from the covered landfill, and a passive gas ventilation system to collect and burn landfill gas. As part of the closure and operation of Landfill No. 5, the Army will continue to monitor groundwater to assist in confirming the prediction of decreasing contamination. If monitoring does not confirm the prediction of decreasing contamination, the Army will evaluate the need to perform additional response action in accordance with all applicable laws and regulations. Administrative controls will be implemented to restrict future development and use of the landfill as identified under an operating or closure permit issued at the landfill.

VIII. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for Fort Lewis Landfill No. 5 was released for public comment on February 6, 1992. The Proposed Plan identified No Action (except continued groundwater monitoring) as the selected remedy for the site. Public comments on the Proposed Plan were evaluated at the end of the 30-day comment period, and it was determined that no significant changes to the Proposed Plan were necessary.

RESPONSIVENESS SUMMARY FORT LEWIS LANDFILL NO. 5

The public comment period on the Proposed Plan was held from February 6 to March 9, 1992. Two sets of written comments were received and are included in Appendix A. A public meeting was held on March 3, 1992 to explain the Proposed Plan and solicit public comments. No questions were asked during the formal comment period of the public meeting. The transcript of the public meeting is available in the Administrative Record. This summary is a response to items raised in the written comments during the public comment period.

1. Re: Page 2 of Proposed Plan - If Landfill No. 5 is not a source of sediment contamination, what is the source?

The likely source of sediment contamination is urban runoff from the drainage area upstream of the landfill. The upstream drainage area includes Ft. Lewis as well as portions of the City of Dupont. Many compounds were found at sampling stations upstream as well as downstream of the landfill. A separate investigation of past and current waste disposal practices in the vicinity of the landfill will be conducted by the U.S. Army to confirm the source of sediment contamination.

2. Why were the levels of benzene and dissolved manganese up in June 1991 if the landfill was already covered?

Although the landfill was covered with a multi-layer cap in 1987-1990, the contamination plume will continue to migrate downgradient from the landfill. Supplemental groundwater sampling and computer modeling results indicate that contaminant concentrations under the landfill and within the contaminant plume itself will decrease with time. The slight increase in benzene and dissolved manganese are within the range of data variability and water level fluctuations expected of groundwater sampling.

- 3. If investigative results showed no change in vinyl chloride and 1,2-dichloroethane [concentration] between October 1989 and September 1991, how can the model show the 30-year average [concentration values] down?**

The investigative results did show that observed concentrations of vinyl chloride and 1,2-dichloroethane were less than detection limits in October 1989 and September 1991; the same is true for TCE and 1,1,2,2-PCA. Table 1 of the Proposed Plan shows the concentration of vinyl chloride to be less than 2 µg/L on both dates. These results should not be interpreted as indicating no change in concentration. When a compound is not detected and/or measured at a value less than the method detection limit (for that compound method and matrix), the concentration of the compound in the sample is reported as "less than detection limit." Using vinyl chloride as an example, the actual sample concentration could be between zero and the compound method detection limit, and will be reported the same way: <2 µg/L, the method detection limit for vinyl chloride. The presence or absence of a trend cannot be concluded from these results for compounds reported solely as less than detection limits.

The model showed that the average concentration of these compounds will decrease over a 30-year period. This result indicates that, as leachate production is reduced at the landfill and as the contamination plume moves away from the landfill, the concentrations of the compounds will decrease by dispersion and dilution. This temporal concentration decrease trend is consistent with the results of the groundwater sampling analyses.

- 4. What is the manufacturer's suggested working life for the high density polyethylene used in capping the East-West landfill zones when the material is used in this type of application? Are there any plans to check liner integrity periodically?**

The 60-mil high-density polyethylene (HDPE) membrane is manufactured by Gundle Lining Systems, Inc. The expected life of the HDPE barrier layer under these conditions is 100 years. The installation of the HDPE layer was monitored for leaks during installation and was subject to a rigorous Quality Assurance/Quality Control

program. Due to reported satisfactory installation, it is unlikely that appreciable water currently infiltrates through the barrier. Future infiltration will have to come through tears in the membrane. If tears were to develop, they would most likely be due to and caused by differential settlement of the waste. Historically, the landfill has not exhibited significant differential settlement. The Landfill No. 5 Operations and Maintenance Manual requires that when a depression is observed on the landfill and a break is suspected in the HDPE barrier the cover must be excavated back to the HDPE barrier and repaired per the manufacturer's recommended techniques. Groundwater will also be monitored to check for excess infiltration to the landfill (see item 5 below).

5. We have several questions regarding the monitoring to be performed as part of the landfill closure:

How frequently will samples be collected as part of the on-going site monitoring? What tests will be performed?

For how many years will the monitoring continue?

Where will the samples be collected? Will the sample sites include both cross-gradient and up-gradient sites as well as the plume areas portrayed in the documentation of the remedial investigation? We would particularly like to see regular monitoring of groundwater in the region between the landfill and the City of DuPont's Bell Hill well site.

Will both surface water and groundwater be sampled?

Groundwater sampling will be conducted as part of ongoing site monitoring. The long-term monitoring plan is being developed at this time. It will contain specifics on sampling locations, frequency and parameters. This plan will be made available to the public through Ft. Lewis.

Will there be additional checks of future monitoring results against computer model predictions to either verify model accuracy of point to the need for additional study?

Future monitoring results will be reviewed and compared against computer model predictions and against previous data observations. Large deviations from expected future concentrations will indicate a need to reassess the situation. Appropriate actions will be taken at that time.

Where and how will the monitoring results be reported? Will the results be available to the public?

Results of the first three rounds of supplemental groundwater sampling program are included in Amendment No. 1 to the RI report and are found in each information repository. Future monitoring results will be reported to the Corps of Engineers and made available to the public through Fort Lewis.

Describe how additional action could be triggered by the water quality monitoring results. Are specific groundwater contaminant concentrations the only activating mechanism, or are there a variety of explicit warning signs established to automatically prompt increased activity? What types of additional action might be required in case of a further deterioration in water quality?

Groundwater monitoring results will be one of the mechanisms used to prompt renewed activity. Excessive differential settlement may also activate additional studies to determine the cause(s) of the settlement. Additional actions which may be required have been discussed in other questions in this response and in the RI Amendments.

- 6. Are there any provisions for on-going monitoring of groundwater level within the landfill or in the immediate vicinity? This might allow early detection of any significant additional groundwater intrusion or progressive changes in water**

table level which could lead to additional pulses of leachate entering the groundwater.

Groundwater levels will be measured during the supplemental groundwater monitoring program described in the previous item.

- 7. What is the status and are there any current results from the separate study of waste disposal practices in the vicinity of the drainage channel, cited in the summary of the proposed plan?**

The work plan for the study is now in preliminary scoping phases. Work on the study of waste disposal practices in the vicinity of the drainage channel has not been started.

- 8. What efforts are being made today to sort and monitor the waste stream entering the landfill? Compare current recordkeeping practices to historical practice, as summarized in the documentation of the remedial investigation.**

Currently, the landfill receives demolition waste (concrete, asphalt, wood, steel, and other construction debris), asbestos, and mixed municipal solid waste (residential, commercial and industrial). Separate records are maintained for each of these waste streams. The mixed municipal wastes are sorted for recyclable materials, and any suspicious materials are removed for special handling. In this manner, the landfill is limited to the designated types of solid wastes.

Table 1: Summary of Organic Compounds Detected in Vashon Drift Wells

Compound (1)	Detection Frequency (2)	D.L. (3)	Concentration, ug/l		
			Min (4)	Max	Mean (5)
Acenaphthene	1/24	1		0.7	
Acetone (6)	3/38	3	<3.0	31.0	2.7
Benzene	14/38	1	0.3	7.8	1.3
Bromoform	1/38	3		0.4	
Bis(2-e.h.)phthalate (6)	10/24	1	0.2	12.0	1.8
Chloroethane	9/38	3	0.6	2.7	1.5
Chloroform (6)	2/38	1		0.3	
1,4-Dichlorobenzene (6)	1/24	1		0.6	
1,1-dichloroethane	28/38	1	0.4	6.8	1.8
1,2-Dichloroethane (6)	4/38	2	0.6	0.8	1.0
1,2-Dichloroethylene	27/28	2	0.5	3.3	1.4
Di-n-octylphthalate (6)	4/24	1	<1.0	6.0	1.0
Diethylphthalate	15/24	1	<1.0	31.0	7.6
Ethylbenzene	6/38	1	0.6	9.4	1.1
Methylene chloride (6)	37/38	2	0.3	4.8	1.7
4-Methylphenol	1/24	1	<1.0	5.0	0.7
Naphthalene (6)	7/24	1	<1.0	17.0	1.9
1,1,2,2-Tetrachloroethane	1/38	2		1.0	
Tetrachloroethylene	1/38	1		0.3	
Toluene (6)	11/38	1	0.4	16.0	1.2
Trichloroethylene	5/38	1	0.3	1.1	0.5
Vinyl chloride	7/38	2	0.8	3.2	1.2
Xylenes	8/38	2	0.4	10.0	1.5

1. Data are presented in Appendix A of Baseline Risk Assessment Report (1991).
2. Number of times detected/number of samples.
3. Detection limit, ug/l.
4. No minimum is shown if maximum is below detection limit.
5. Mean is calculated using one-half the detection limit for results reported as "non-detects." Mean is not calculated if maximum is below detection limit.
6. Analyte was detected in method blanks and field blanks.

Table 2: Summary of Inorganic Compounds Detected in Vashon Drift Wells

Compound	Detection Frequency (2)	D.L. (3)	Concentration, ug/l (1)		
			Minimum	Maximum	Mean (4)
Barium	40/40	1	5	155	32
Cadmium	1/40	2	<2	3	1
Chromium	9/40	5	5	38	4
Iron	40/40	5	34	32100	4608
Manganese	40/40	1	2	10700	2216
Mercury	1/40	0.1	<0.1	0.2	0.05

1. Concentrations are for total inorganics.
2. Number of times detected/number of samples.
3. Detection Limit, ug/l.
4. Mean is calculated using one-half the reporting limit for results reported as "non-detects."

Table 3: Summary of Compounds Detected In Salmon Springs Wells

Compound (1)	Detection Frequency (2)	D.L. (3)	Concentration, ug/l		
			Min (4)	Max	Mean (5)
Benzene	4/14	1	<1.0	3.2	1.1
Bis(2-e.h.)phthalate (6)	2/12	1	<1.0	1.0	0.6
Chloroethane	3/14	3	0.7	1.5	1.4
1,1-dichloroethane	4/14	1	0.7	1.9	0.7
1,2-Dichloroethylene	4/14	2	0.3	1.2	0.9
Diethylphthalate	3/12	1	<1.0	11.0	2.9
1,1,2,2-Tetrachloroethane	1/14	2		0.8	
Toluene (6)	1/14 (7)	1		0.2	
Trichloroethylene	1/14	1	<1.0	2.5	0.6
Vinyl chloride	2/14	2	0.7	1.3	1
Xylenes	1/14	2		0.5	
Barium	10/12	1	4	102	25.6
Chromium	8/12	5	<5	136	28.7
Iron	12/12	5	170	18900	3736
Manganese	12/12	1	19	4210	844
Mercury	1/12	0.1		0.1	

1. Inorganics are reported as total concentrations.
Identified laboratory contaminants are not shown.
2. Number of times detected/number of samples.
3. Detection limit, ug/l.
4. No minimum is shown if maximum is below detection limit.
5. Mean is calculated using one-half the detection limit for results reported as "non-detects." Mean is not calculated if maximum is below detection limit.
6. Analyte was detected in method blanks and field blanks.
7. The single positive result for toluene is reported here. Three other occurrences were due to field or laboratory contamination.

Table 4: Summary of Compounds Detected In Sequalitchew Delta Wells

Compound (1)	Detection Frequency (2)	D.L. (3)	Concentration, ug/l		
			Min (4)	Max	Mean (5)
Bis(2-e.h.)phthalate	1/4	1		1.0	
1,1,2,2-Tetrachloroethane	1/8	2		1.3	
Barium	6/6	1	3	9	5
Chromium	6/6	5	72	738	326
Iron	6/6	5	450	4510	1760
Manganese	6/6	1	12	120	48

1. Inorganics are reported as total concentrations.
Identified laboratory contaminants are not shown.
2. Number of times detected/number of samples.
3. Detection limit, ug/l.
4. No minimum is shown if maximum is below detection limit.
5. Mean is calculated using one-half the detection limit for results reported as "non-detects." Mean is not calculated if maximum is below detection limit.

Table 5: Summary of Surface Water Sampling Results

Volatile Organic Compounds	Detection Limit (ug/L)	Range of Concentration (ug/L)	Frequency of Detection
Vinyl Chloride	2	<	0/16
Chloroethane	3	<	0/16
Methylene Chloride	2	0.3 MBb - 2.4 Bb	15/16
Acetone	3	7.0	1/16
1,1-Dichloroethane	1	<	0/16
Total 1,2-Dichloroethene	2	0.3 M	1/16
Chloroform	1	<	0/16
1,2-Dichloroethane	2	<	0/16
1,1,1-Trichloroethane	1	0.4 Mb - 0.5 Jb	2/16
Trichlorofluoromethane	5	<	0/16
Trichloroethene	1	0.7 Jb - 1.5 b	2/16
Tetrachloroethane	1	<	0/16
Benzene	1	<	0/16
Bromoform	3	<	0/16
1,1,2,2-Tetrachloroethane	2	<	0/16
Toluene	1	0.3 MBb - 0.5 MBb	4/16
Ethyl Benzene	1	<	0/16
Total Xylenes	2	<	0/16
1,1,2-Trichloro 1,2,2-trifluoroethane	5	<	0/16
Ethyl Ether	TIC	<	0/2
Hexane	TIC	<	0/2
Dichlorofluoromethane	TIC	<	0/8

Base/Neutral and Acid-Extractable Compounds	Detection Limit (ug/L)	Range of Concentration (ug/L)	Frequency of Detection
Phenol	2	<	0/16
1,4-Dichlorobenzene	1	<	0/16
Naphthalene	1	<	0/16
Diethylphthalate	1	0.2 J	1/16
Acenaphthene	1	<	0/16
bis (2-Ethylhexyl) Phthalate	1	0.2 Jb - 7 b	4/16
Di-n-Octyl Phthalate	1	1 B	1/16
4-Methylphenol	1	<	0/16
Benzamide, N,N-Diethyl-3-methyl	TIC	<	0/8
4-(1,1-Dimethylethyl)-Benzoic Acid	TIC	<	0/8
3-Methyl-Benzoic Acid	TIC	<	0/8
Sulfur, Molecular (S8)	TIC	<	0/8
Ethanol, 2-Butoxy-Phosphate (3:1)	TIC	<	0/8
N-ethyl-4-methyl-Benzenesulfonamide	TIC	<	0/8
Sulfonamide Isomer	TIC	<	0/8
Alkyl-benzoic Acid Isomer	TIC	<	0/8
1,7,7, Trimethyl-Bicyclo (2.2.1) Heptan-2-one	TIC	<	0/8

Inorganic Compounds (Dissolved)	Detection Limit (ug/L)	Range of Concentration (ug/L)	Frequency of Detection
Iron (Fe)	5	8 - 1610 b	26/33
Zinc (Zn)	4	4 - 31	20/33
Barium (Ba)	1	2 - 45	32/33
Manganese (Mn)	1	1 - 145	26/33
Cadmium (Cd)	2	2	1/33
Mercury (Hg)	0.1	0.1 B	1/33

< = Analyte below detection limit

J : Estimated value less than specified detection limit

B : Analyte also found in laboratory blank

b : Analyte also found in field blank

M : Estimated value of analyte found and confirmed by analyst but with low spectral match parameters

TIC : Tentatively Identified Compound

Table 6: Summary of Sediment Sampling Results

Volatile Organic Compound Concentrations	Detection Limit (ug/kg)	Range of Concentration (ug/kg)	Frequency of Detection
Chloromethane	<4.4 - <45	1.1 M	1/10
Bromomethane	<3.2 - <27	5.6 M	1/10
Methylene Chloride	.	0.9 B - 31 B	10/10
Acetone	<3.3 - <11	2.2 J - 200	6/10
2-Butanone	<6.5 - <27	1.9 J - 43	4/10
Toluene	<0.9 - <8.9	1.1 J - 67	3/10
Styrene	<1.1 - <8.9	0.5 M	1/10
1,1,2-Trichloro 1,2,2-trifluoroethane	<4.4 - <20	2.3 J - 14 M	3/10

Base/Neutral and Acid-Extractable Compound Concentrations	Detection Limit (ug/kg)	Range of Concentration (ug/kg)	Frequency of Detection
Phenol	<120 - <900	260 J	1/10
4-Methylphenol	<62 - <380	59 J - 1100	3/10
2-Methylnaphthalene	<61 - <450	29 M	1/10
Fluorene	<61 - <450	29 M	1/10
N-Nitrosodiphenylamine	<61 - <450	120	1/10
Pentachlorophenol	<300 - <1900	1500 J	1/10
Phenanthrene	<61 - <380	35 J - 240 M	2/10
Anthracene	<61 - <450	53 J	1/10
Di-n-Butylphthalate	<61 - <450	33 M	1/10
Fluoranthene	<61 - <200	77 - 470	3/10
Pyrene	<61 - <200	120 - 650	3/10
Benzo(a) Anthracene	<61 - <450	120	1/10
bis (p-ethoxy) Phthalate	<61 - <200	140 J - 1100	4/10
Chrysene	<61 - <380	28 J - 350 J	2/10
Benzo(b,k)-Fluoranthene	<61 - <380	250 - 390 J	2/10
Benzo(a)-Pyrene	<61 - <450	57 M	1/10

Inorganic Compound Concentrations	Detection Limit (ug/kg)	Range of Concentration (ug/kg)	Frequency of Detection
Silver (Ag)	<0.2 - <2.0	<	0/10
Arsenic (As)	.	2.8 J - 94.2 J	10/10
Barium (Ba)	.	34.2 - 163	10/10
Beryllium (Be)	<0.3 - <0.7	0.1 - 0.4	7/10
Cadmium (Cd)	<0.1 - <0.6	0.4 - 7.0	5/10
Chromium (Cr)	.	11.1 - 46.7	10/10
Copper (Cu)	.	8.7 J - 177 J	10/10
Iron (Fe)	.	4900 - 64300	10/10
Mercury (Hg)	<0.04 - <0.14	0.022 - 0.56	6/10
Manganese (Mn)	.	46.9 - 1140	10/10
Nickel (Ni)	.	13 - 45	10/10
Lead (Pb)	<3	7 - 344	8/10
Antimony (Sb)	<3 - <34	<	0/10
Selenium (Se)	<0.37 - <3.06	<	0/10
Thallium (Tl)	<6 - <34	7 - 13	5/10
Zinc (Zn)	.	25.1 - 441	10/10

Pesticide Estimated Concentrations	Detection Limit (ug/kg)	Range of Concentration (ug/kg)	Frequency of Detection
4,4'-DOE	<6.0 - <28	8.3 J	1/10
4,4'-DDD	<6.0 - <14	3.7 J - 20	3/10

< = Analyte below detection limit.

B : Analyte also found in laboratory blank

J : Estimated value less than specified detection limit

M : Estimated value of analyte found and confirmed by analyst but with low spectral match parameters

. : Constituent was detected in all samples

**Table 7: Permanent Gases (%) and Volatile Organic Compound (ppb)
Concentrations in Landfill Gas Samples**

Permanent Gases	Detection Limit	Flare 2	Flare 5	Flare 8	Mean (4)
Oxygen	0.1	1	4	4 [7.9]	3
Nitrogen	0.1	3	16	23 [24]	14
Methane	0.1	53	44	36 [37]	44
Carbon Dioxide	0.1	43	37	35 [35]	38
Volatile Organic Compounds*					
Freon 12 (1)	200	4800	3100	4700 [5300]	4200
Freon 114 (2)	200	<	170	260 [300]	177
Vinyl chloride	300	3600	1700	1100 [1200]	2133
Chloroethane	500	1100	830	760 [960]	897
Freon 11 (3)	200	1200	1900	3100 [3500]	2067
cis-1,2-Dichloroethene	300	1300	780	390 [440]	823
Freon 113	200	420	540	780 [840]	580
Methylene Chloride	200	8200	4000	4100 [4500]	5433
1,1,1-Trichloroethane	300	350	460	820 [880]	543
Benzene	200	1100	800	660 [740]	853
1,3,5-Trimethylbenzene	200	200	220	210 [200]	210
1,4-Dichlorobenzene	100	97	140	170 [180]	136
Toluene	200	15000	9600	9200 [8800]	11266
1,2,4-Trichlorobenzene	200	<	420	<[<] [370]	206
1,2,4 - Trimethylbenzene	200	460	<	370 [370]	310
Trichloroethene	200	530	270	490 [510]	430
Tetrachloroethene	200	540	240	220 [230]	333
Ethylbenzene	200	1700	1500	1300 [1400]	1500
m,p-Xylenes	200	3800	3300	3000 [3000]	3367
o-Xylene	200	1100	950	910 [930]	987

[] : Denotes results of field duplicate.

* Detection limit shown represents analysis for a dilution factor equal to 1000. All field samples required dilution between 800 - 1000.

1. Dichlorodifluoromethane (Freon 12)
2. 1,1 - Dichloro - 1,2,2,2 - tetrafluoroethane (Freon 114)
3. Trichlorofluoromethane (Freon 11)
4. Mean of three samples.

Table 8: Summary of Chemicals of Concern

GROUNDWATER	SEDIMENTS	AIR
<u>Carcinogens</u>	<u>Carcinogens</u>	<u>Carcinogens</u>
benzene 1,2-dichloroethane 1,1,2,2-tetrachloroethane trichloroethylene vinyl chloride	benzo(b/k)fluoranthene chrysene pentachlorophenol arsenic	benzene methylene chloride trichloroethylene vinyl chloride
<u>Noncarcinogens</u>	<u>Noncarcinogens</u>	<u>Noncarcinogens</u>
manganese naphthalene	pentachlorophenol arsenic	1,2-dichloroethylene 1,4-dichlorobenzene dichlorodifluoromethane ethylbenzene methylene chloride toluene tetrachloroethylene trichlorofluoromethane 1,2,4-trichlorobenzene 1,1,1-trichloroethane xylenes

Table 9: Modeled Concentrations of Chemicals of Concern In Groundwater
($\mu\text{g/l}$)

COMPOUND	Well 88-LS-AX-VD		Well 89-17-VD	
	10 Year Average	30 Year Average	10 Year Average	30 Year Average
Benzene	0.86	0.64	0.64	0.38
1,2-Dichloroethane	0.19	0.12	0.13	0.07
Naphthalene	1.13	1.36	0.000228	0.01
1,1,2,2-Tetrachloroethane	0.62	0.36	0.1	0.12
Trichloroethylene	0.12	0.09	0.09	0.05
Vinyl Chloride	0.39	0.23	0.24	0.12
Manganese (mg/l)	1.31	0.77	0.79	0.39

Table 10: Maximum Ambient Air Quality Impacts from Landfill Vents ISCLT

COMPOUND	MOL WT	CONC (ppb)	FLOW RATE (cfm/sack)	EMISSION RATE (g/SEC)	MAX. ANNUAL IMPACT AT FENCELINE		ONSITE ANNUAL IMPACT AT 22.5 deg, 600m		INDUSTRIAL ANNUAL IMPACT AT 292.5 deg, 1000m	
					CHVQ CONC. (MG/M3)	COMPOUND CONC. (MG/M3)	CHVQ CONC. (MG/M3)	COMPOUND CONC. (MG/M3)	CHVQ CONC. (MG/M3)	COMPOUND CONC. (MG/M3)
benzene	78	863	11.1	1.472E-06	1.196E-01	1.768E-06	1.029E-01	1.614E-06	1.926E-02	2.834E-07
1,4-dichlorobenzene	147	136	11.1	4.422E-06	1.196E-01	6.284E-07	1.029E-01	4.660E-07	1.926E-02	6.616E-08
1,2-dichloroethane	97	823	11.1	1.768E-06	1.196E-01	2.110E-06	1.029E-01	1.617E-06	1.926E-02	3.401E-07
ethylbenzene	106	1600	11.1	3.617E-06	1.196E-01	4.203E-06	1.029E-01	3.619E-06	1.926E-02	6.773E-07
iron 11	137	2087	11.1	6.263E-06	1.196E-01	7.486E-06	1.029E-01	6.446E-06	1.926E-02	1.206E-06
iron 12	121	4200	11.1	1.124E-04	1.196E-01	1.343E-06	1.029E-01	1.167E-06	1.926E-02	2.166E-06
methylene chloride	86	6433	11.1	1.021E-04	1.196E-01	1.221E-06	1.029E-01	1.061E-06	1.926E-02	1.997E-06
tetrachloroethylene	166	333	11.1	1.223E-06	1.196E-01	1.461E-06	1.029E-01	1.264E-06	1.926E-02	2.366E-07
toluene	92	11264	11.1	2.292E-04	1.196E-01	2.740E-06	1.029E-01	2.369E-06	1.926E-02	4.416E-06
1,2,4-trichlorobenzene	181	208	11.1	4.247E-06	1.196E-01	9.666E-07	1.029E-01	8.488E-07	1.926E-02	1.668E-07
1,1,1-trichloroethane	133	643	11.1	1.637E-06	1.196E-01	1.909E-06	1.029E-01	1.644E-06	1.926E-02	3.076E-07
trichloroethylene	131	430	11.1	1.246E-06	1.196E-01	1.469E-06	1.029E-01	1.262E-06	1.926E-02	2.400E-07
vinyl chloride	63	2133	11.1	2.972E-06	1.196E-01	3.662E-06	1.029E-01	3.066E-06	1.926E-02	6.724E-07
m,p-xylene	106	3367	11.1	7.894E-06	1.196E-01	9.433E-06	1.029E-01	8.123E-06	1.926E-02	1.620E-06
o-xylene	106	947	11.1	2.314E-06	1.196E-01	2.766E-06	1.029E-01	2.381E-06	1.926E-02	4.467E-07

Table 11: Concentrations of Chemicals of Concern in Drainage Channel Sediments, mg/kg

Compound	Location			
	Upgradient SC-4,DC-1		Adjacent DC-2,DC-3	
	Mean (1)	Max	Mean (1)	Max
Benzo(b/k)fluoranthene	0.059	0.085	0.290	0.390
Chrysene	0.056	0.085	0.270	0.350
Pentachlorophenol	0.300	0.435	1.225	1.500
Arsenic	16.000	20.000	62.000	94.000

1. Average of two samples.

Table 12: Toxicity Factors for Chemicals of Concern

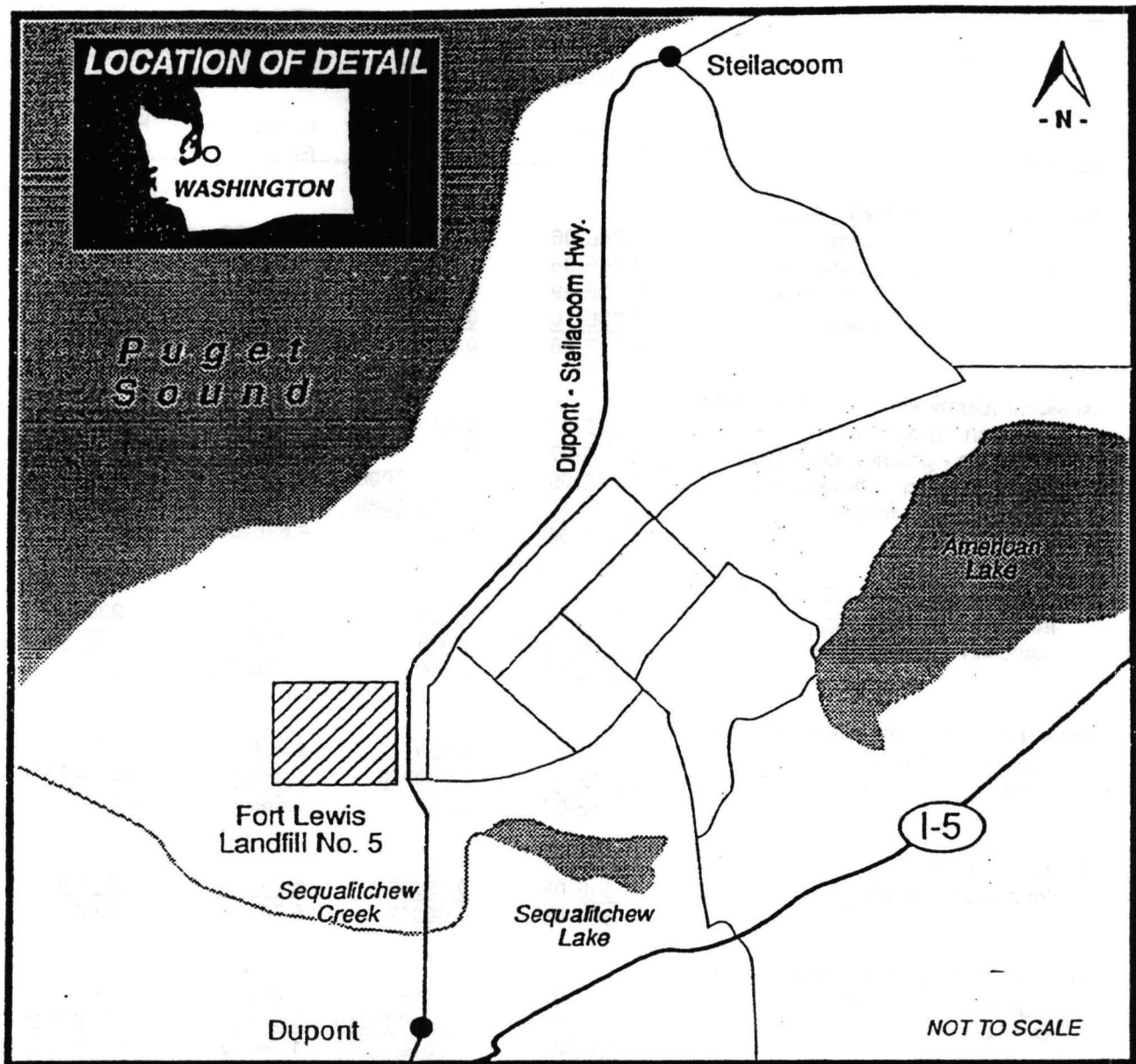
Compound	Chronic Reference Dose (mg/kg-day)		Slope Factor 1/(mg/kg-day)		Weight of Evidence Class	Source*
	Inhalation	Oral	Inhalation	Oral		
Benzene			2.9E-02	2.9E-02	A	IRIS
Benzo(b/k)fluoranthene				8.4E-01	B2	(1)
Chrysene				5.0E-02	B2	(1)
1,4-Dichlorobenzene	2.0E-01					HEAST
1,2-Dichloroethane			9.1E-02	9.1E-02	B2	IRIS
1,2-Dichloroethylene	1.0E-02					HEAST (5)
Freon 12 (2)	5.0E-02					HEAST
Ethylbenzene	2.9E-01					HEAST
Methylene chloride	8.6E-01		1.6E-03		B2	IRIS
Naphthalene	4.0E-03	4.0E-03				HEAST (5)
Pentachlorophenol		3.0E-02	1.2E-01		B2	IRIS;HEAST
1,1,2,2-Tetrachloroethane			2.0E-01	2.0E-01	C	IRIS
Tetrachloroethylene	1.0E-02		1.8E-03		B2	HEAST
Toluene	6.0E-01					HEAST
1,2,4-Trichlorobenzene	3.0E-03					HEAST
1,1,1-Trichloroethane	3.0E-01					HEAST
Trichloroethylene			6.0E-03	1.1E-02	B2	HEAST
Freon 11 (3)	2.0E-01					HEAST
Vinyl chloride			2.9E-01	1.9E+00	A	HEAST
Xylenes	8.6E-02					HEAST
Arsenic		1.0E-03	5.0E+01	1.8E+00(4)	A	HEAST;IRIS
Manganese		1.0E-01				IRIS

* Sources: EPA Integrated Risk Information System (IRIS), on-line database.
EPA Health Effects Assessment Summary Tables (HEAST), 1991.

1. Derived from oral slope factor for benzo(a)pyrene of 11.5 1/(mg/kg-day) (HEAST 1991).
2. Dichlorodifluoromethane
3. Trichlorofluoromethane
4. Derived from proposed unit risk of 5E-05 1/(ug/l).
5. Oral toxicity value adopted for inhalation pathway.

Table 13: Summary of Estimated Health Risks

Receptor/Pathway	Average Exposure		Reasonable Maximum Exposure	
	Cancer Risk	Chronic Hazard Index	Cancer Risk	Chronic Hazard Index
Resident (fenceline, well LS-Ax-VD)				
Ingestion - groundwater	1.76E-06	0.20	6.33E-06	0.22
Inhalation - groundwater VOCs	1.46E-06	0	7.49E-06	0
Dermal contact - showering	2.28E-09	0.0000055	1.38E-07	0.00020
Inhalation - landfill gas	<u>7.29E-10</u>	<u>0.0000055</u>	<u>4.86E-09</u>	<u>0.000011</u>
	3.23E-06	0.20	1.40E-05	0.22
Resident (plume edge, well 89-17-VD)				
Ingestion - groundwater	9.83E-07	0.12	3.17E-06	0.11
Inhalation - groundwater VOCs	6.30E-07	0	3.39E-06	0
Dermal contact - showering	1.27E-09	0.000000011	6.93E-08	0.0000015
Inhalation - landfill gas	<u>1.17E-10</u>	<u>0.00000088</u>	<u>7.83E-10</u>	<u>0.0000018</u>
	1.61E-06	0.12	6.63E-06	0.11
Worker (fenceline, well LS-Ax-VD)				
Inhalation - landfill gas	1.90E-08	0.00014	7.77E-08	0.00021
Ingestion - groundwater	<u>5.71E-07</u>	<u>0.066</u>	<u>1.89E-06</u>	<u>0.079</u>
	5.91E-07	0.066	1.96E-06	0.079
Worker (plume edge, well 89-17-VD)				
Ingestion - groundwater	3.19E-07	0.039	9.43E-07	0.038
Inhalation - landfill gas	<u>3.06E-09</u>	<u>0.000023</u>	<u>1.25E-08</u>	<u>0.000034</u>
	3.22E-07	0.039	9.56E-07	0.038
Worker (onsite)				
Inhalation - landfill gas	<u>1.64E-08</u>	<u>0.00012</u>	<u>6.70E-08</u>	<u>0.00018</u>
	1.64E-08	0.00012	6.70E-08	0.00018
Trespasser (upgradient drainage channel)				
Ingestion - sediment	1.34E-07	0.0019	1.34E-06	0.019
Dermal contact - sediment	<u>7.02E-12</u>	<u>0.000000010</u>	<u>1.97E-09</u>	<u>0.0000029</u>
	1.34E-07	0.0019	1.34E-06	0.019
Trespasser (adjacent drainage channel)				
Ingestion - sediment	5.20E-07	0.0075	6.29E-06	0.091
Dermal contact - sediment	<u>3.45E-11</u>	<u>0.000000043</u>	<u>8.97E-09</u>	<u>0.000010</u>
	5.20E-07	0.0075	6.30E-06	0.091
Resident, Subchronic				
Ingestion - groundwater		0.2	<u>Subchronic Hazard Index</u>	
				0.36



Project No. 8820072

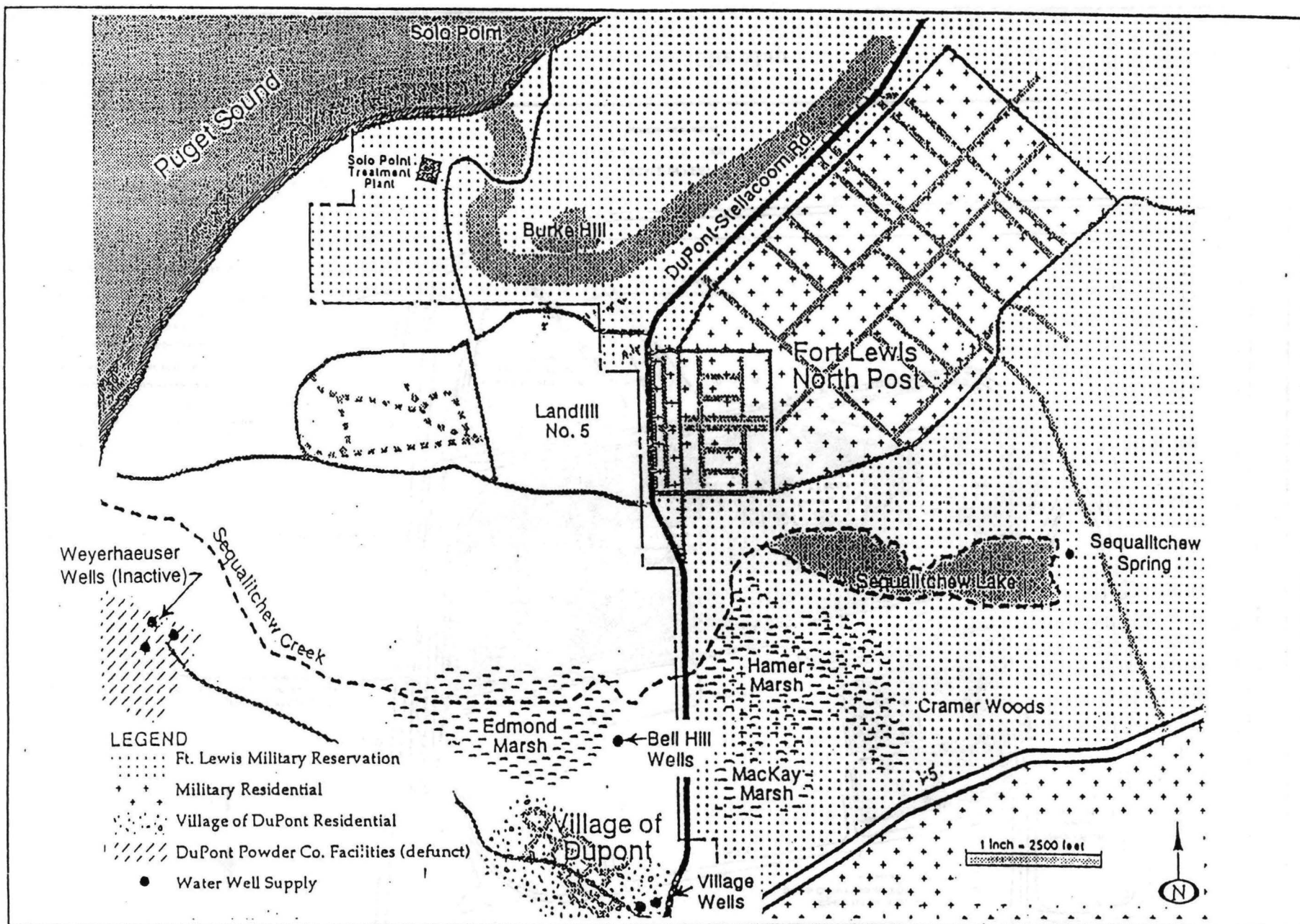
Fort Lewis Landfill No. 5

Fort Lewis Landfill No. 5
Location Map

Figure 1

Woodward-Clyde Consultants





Project No. 8820072

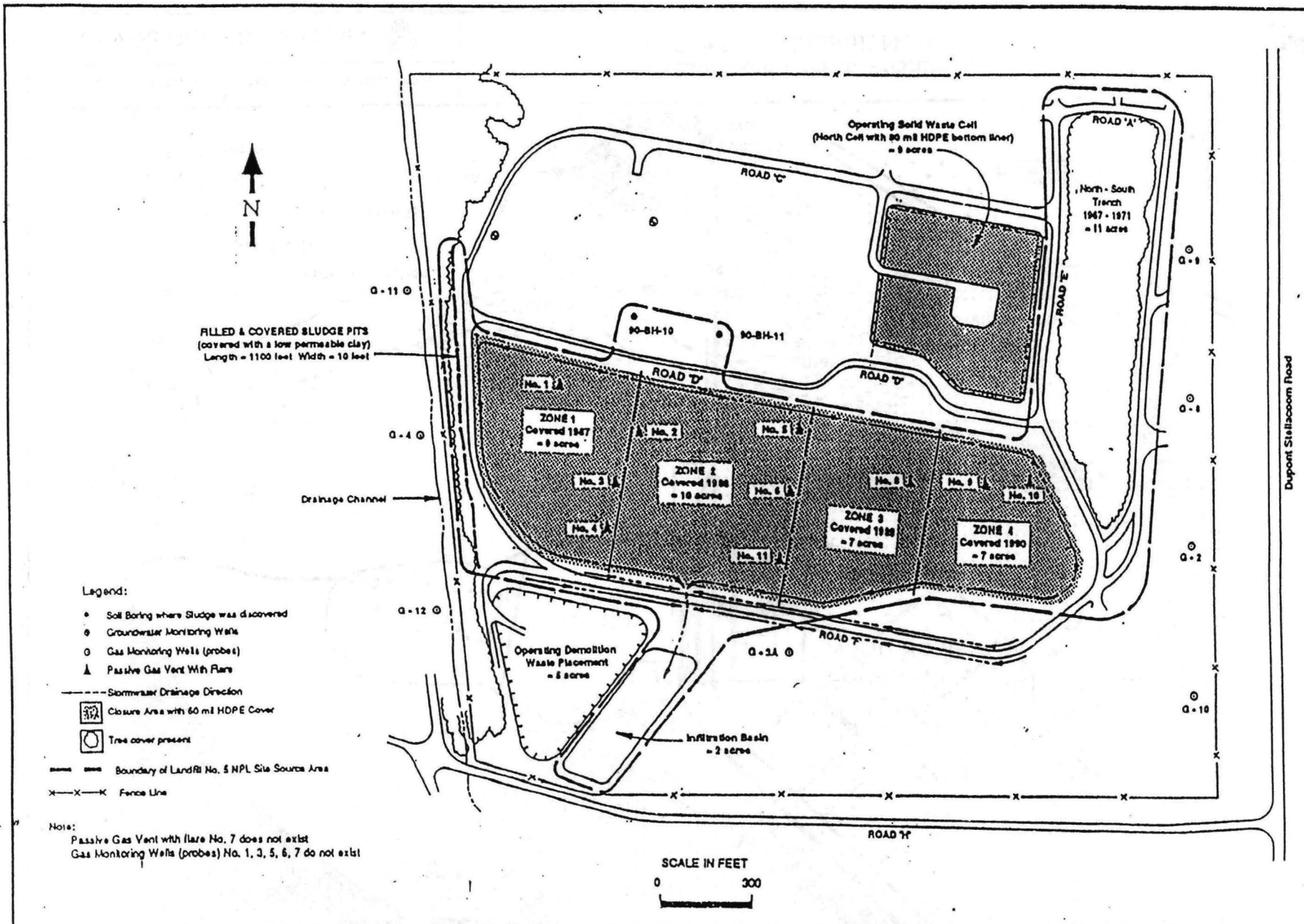
Fort Lewis Landfill No. 5

Woodward-Clyde Consultants



Existing Land Uses in Vicinity
of Fort Lewis Landfill No. 5

Figure 2



Project No. 8820072

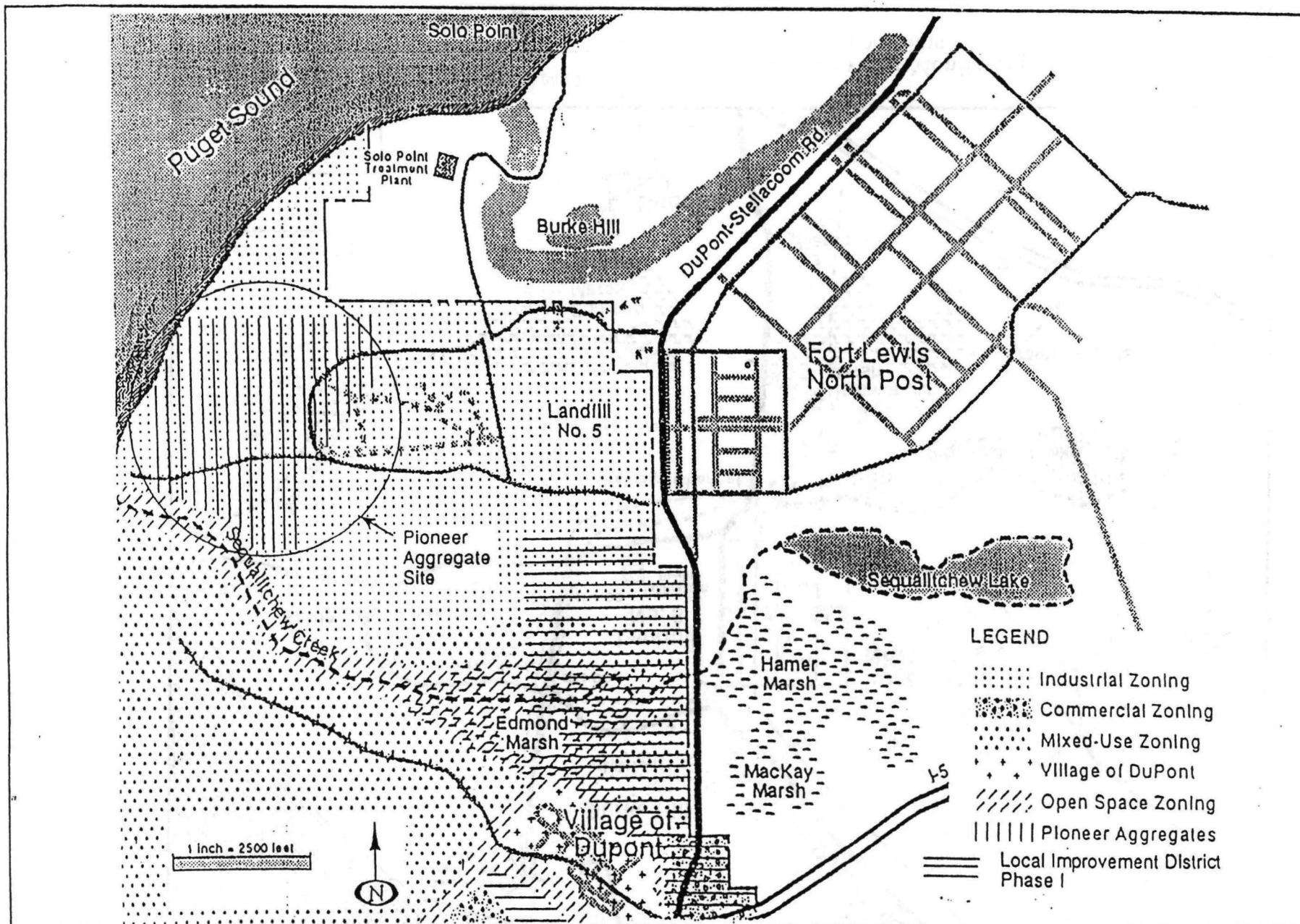
Fort Lewis Landfill No. 5

Site Map

Figure 3

Woodward-Clyde Consultants





Project No. 8820072

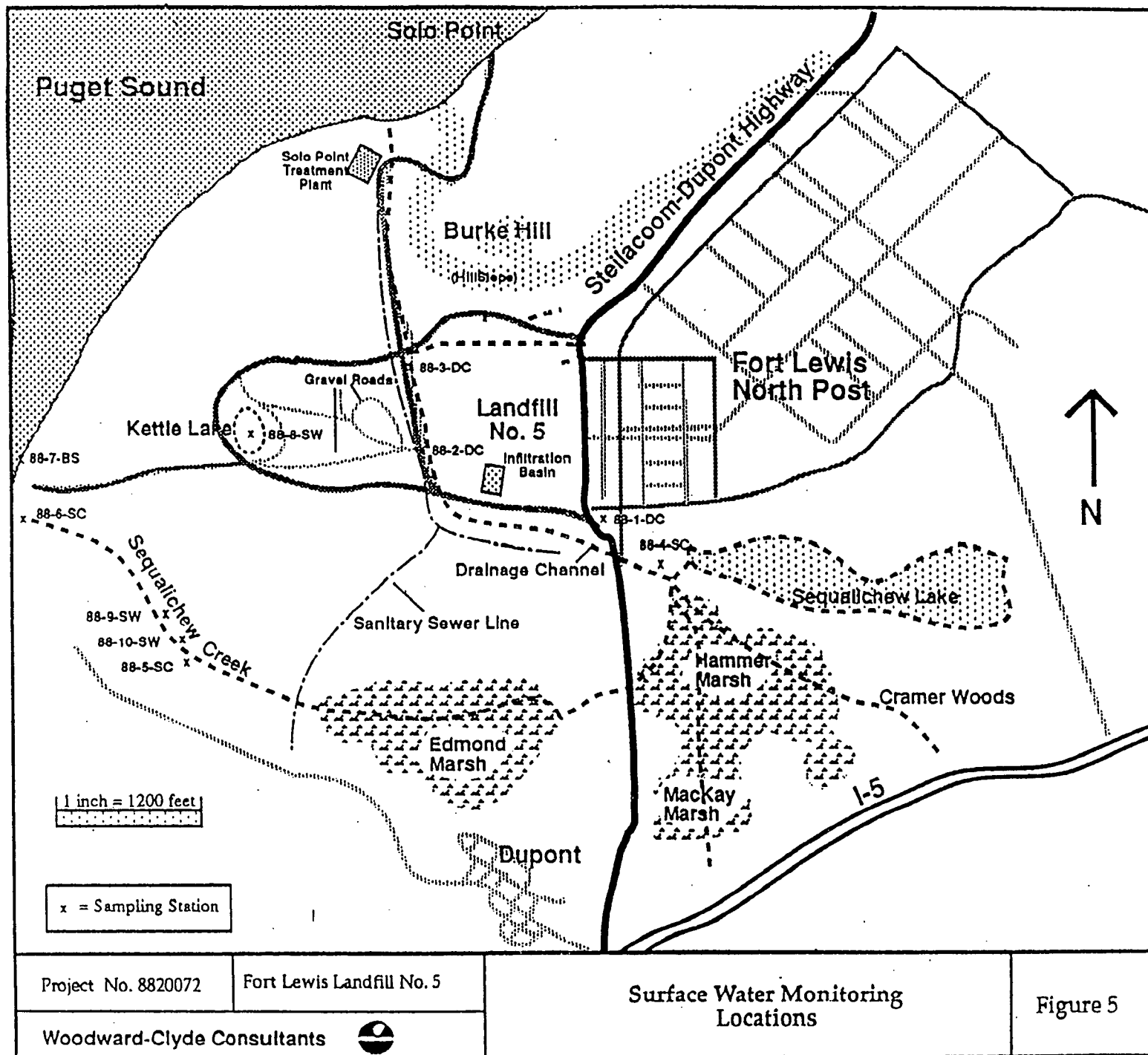
Fort Lewis Landfill No. 5

Woodward-Clyde Consultants



Planned and Proposed Future Land Uses in Vicinity
of Ft. Lewis Landfill No. 5

Figure 4



	<u>LITHOLOGY</u>	<u>CLIMATE</u>
Vashon Drift	Steilacoom Gravel	Glacial
	Recessional Gravel	
	Till	
	Advance Gravel	
	Colvos Sand	
	Kitsap Formation	Nonglacial
	Salmon Springs Drift	Glacial
	Puyallup Formation	Nonglacial
	Stuck Drift	Glacial
	Alderton Formation	Nonglacial
	Orting Drift	Glacial
	Undifferentiated Miocene	Nonglacial
	Eocene Bedrock	

Project
No. 8820072

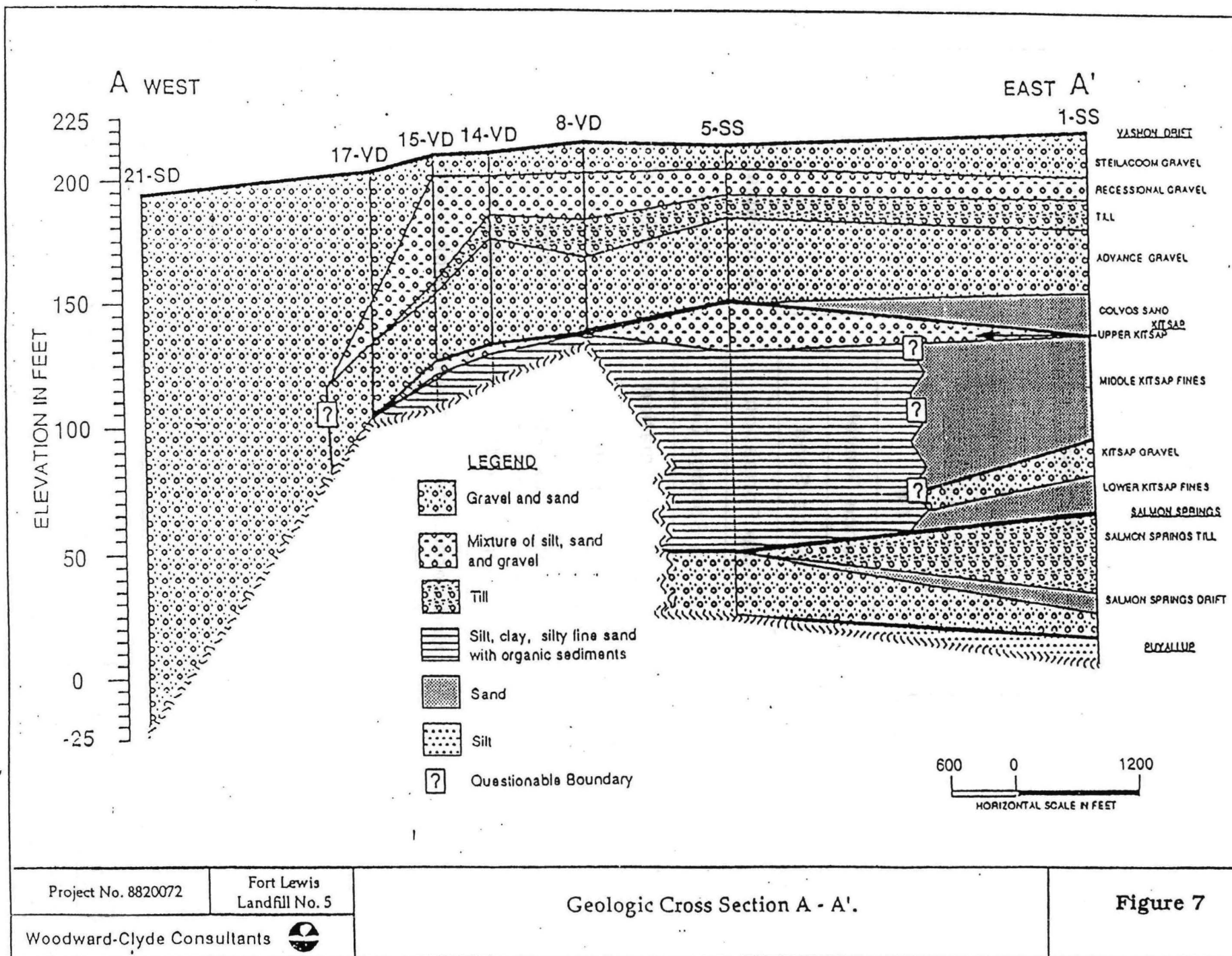
Fort Lewis
Landfill No. 5

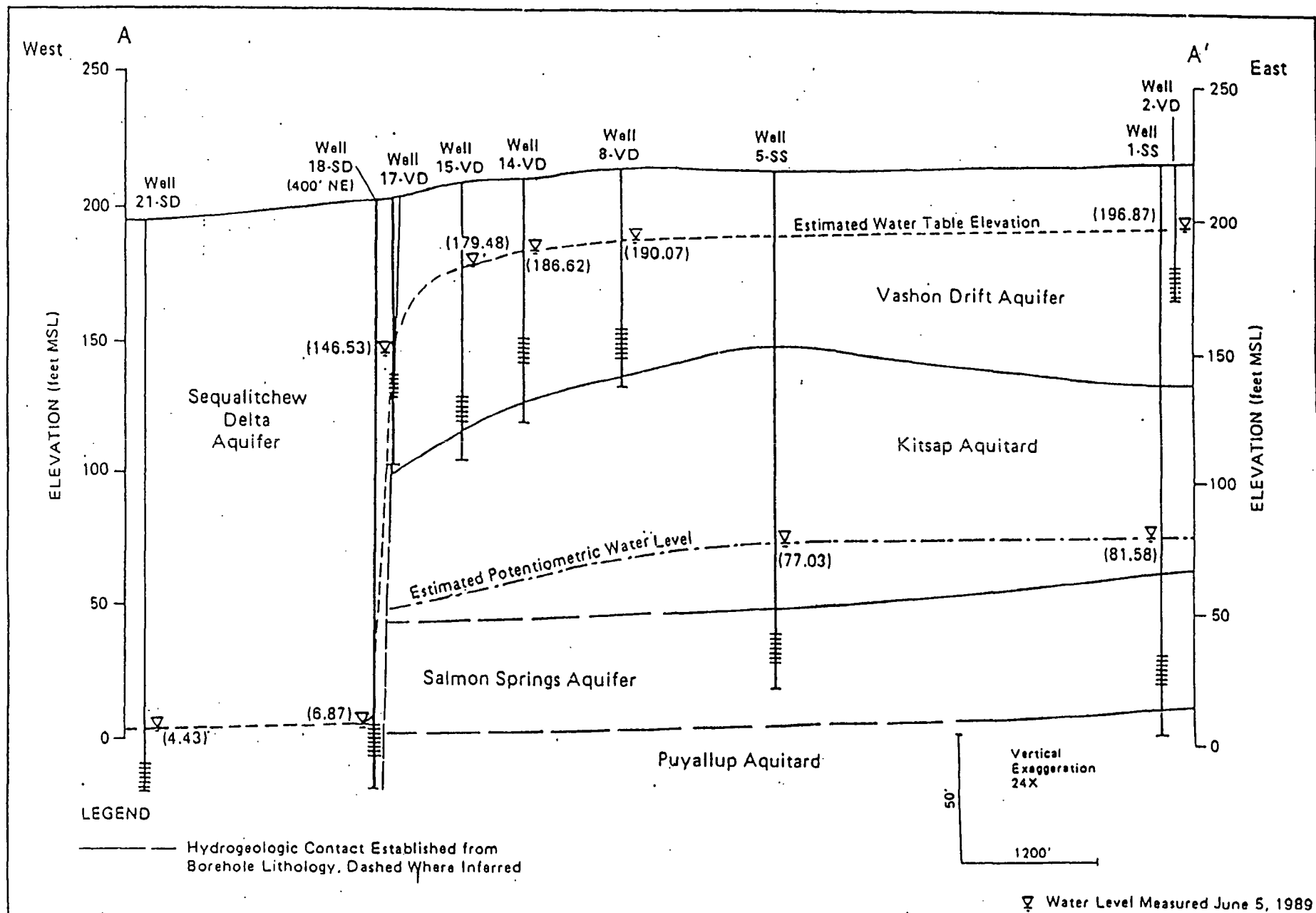
Regional Stratigraphic Column

Figure 6

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Project No. 8820072

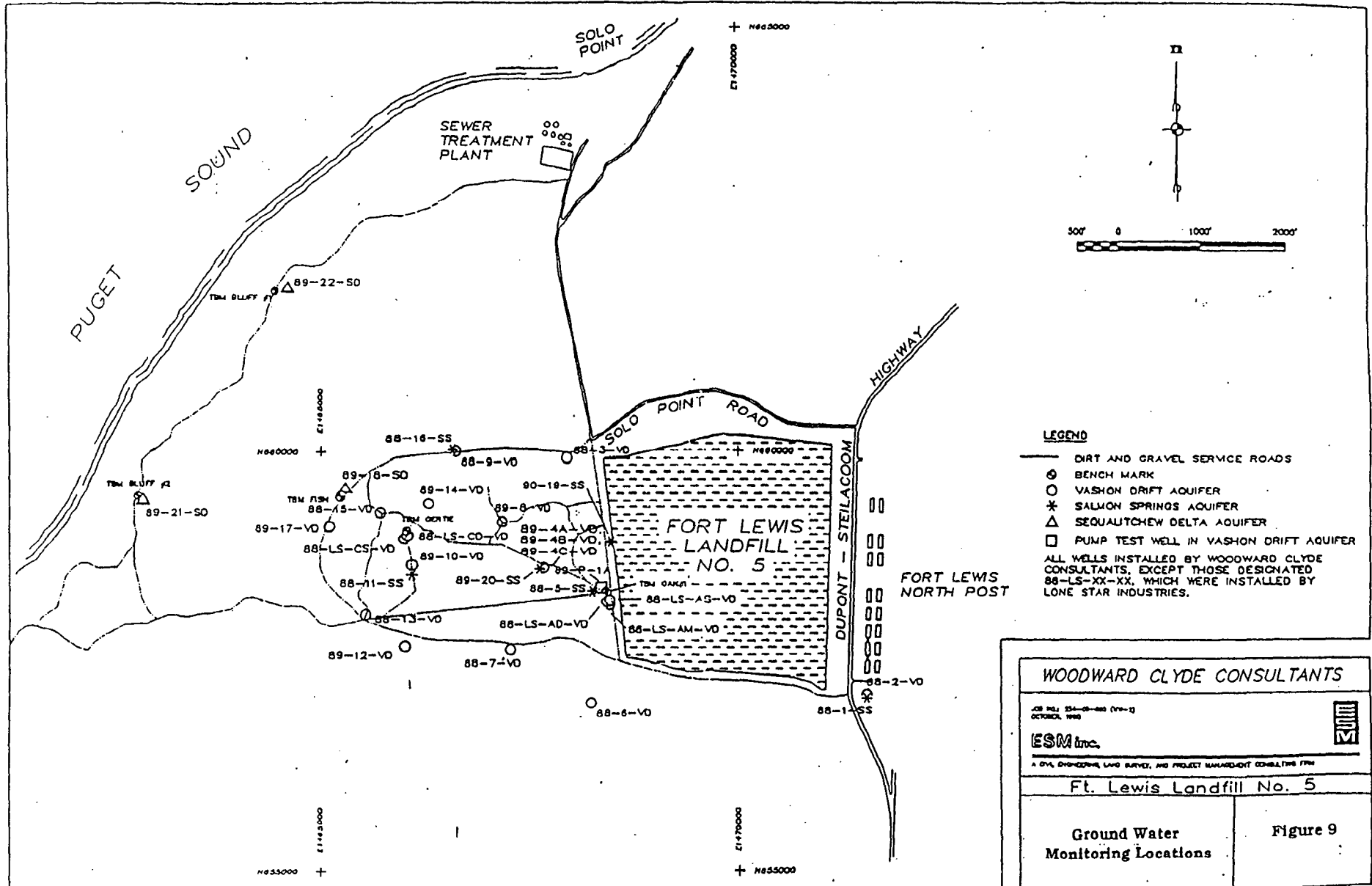
Fort Lewis Landfill No. 5

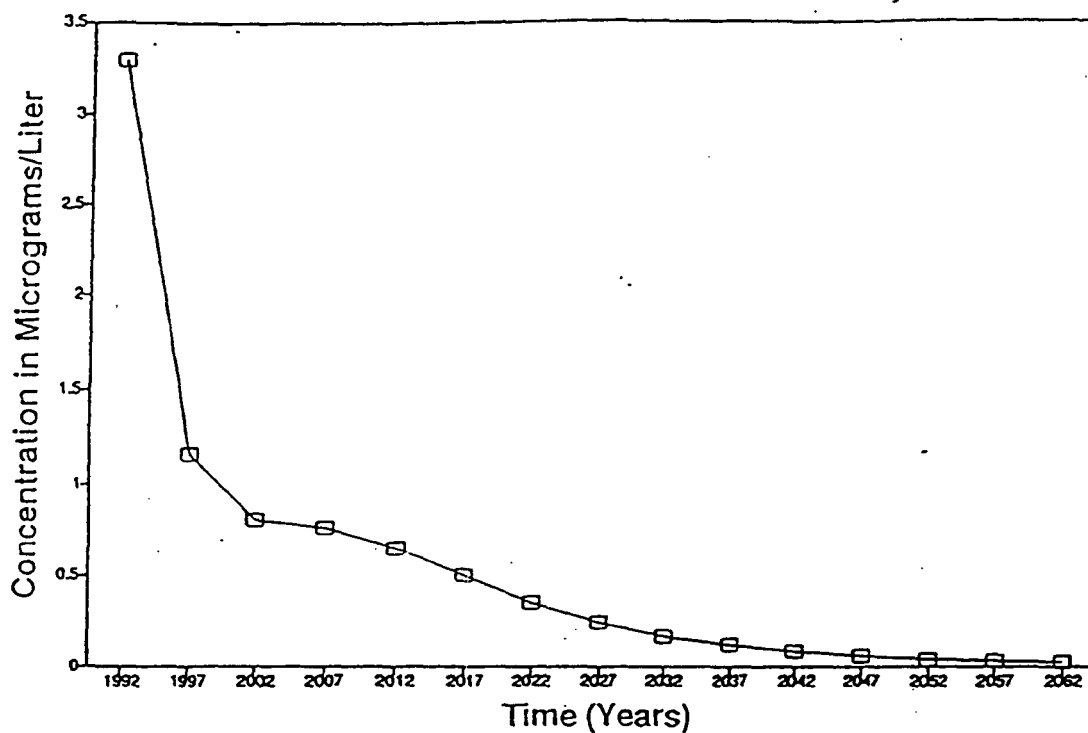
Woodward-Clyde Consultants



Hydrogeologic Cross Section A-A'

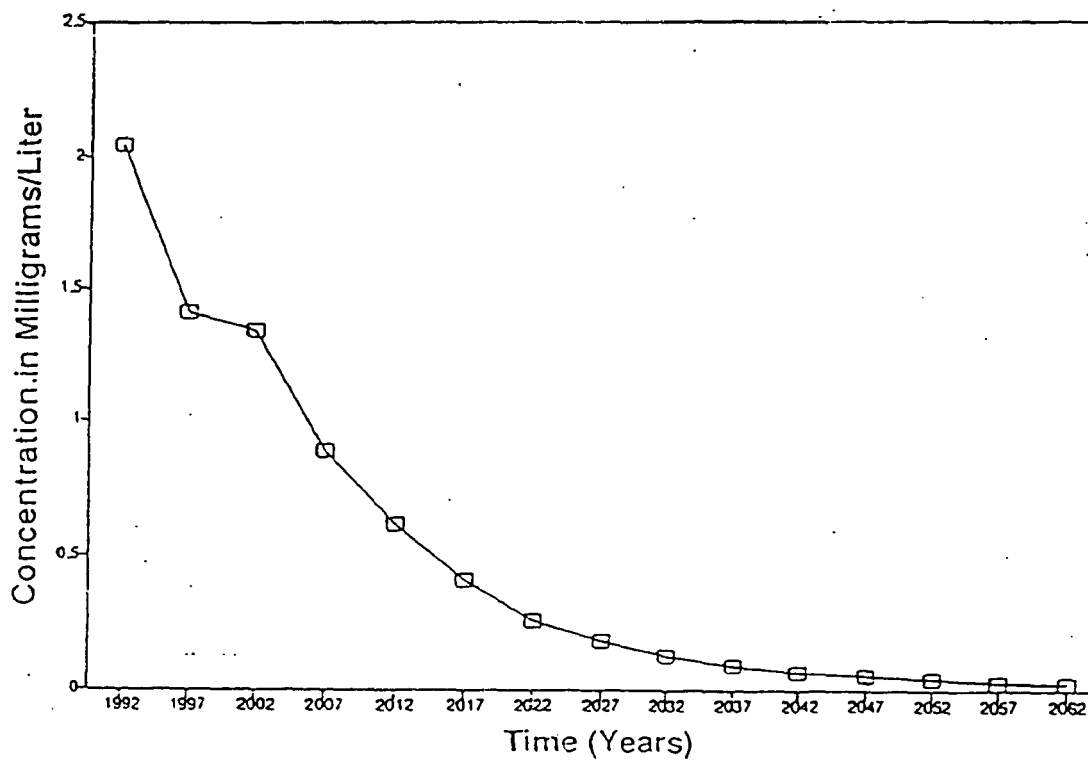
Figure 8





**MODELED CONCENTRATIONS: Benzene Arrival Pattern
at Well 88-LS-AX-VD**

Figure 10



**MODELED CONCENTRATIONS:
Total Manganese Arrival Pattern
at Well 88-LS-AX-VD**

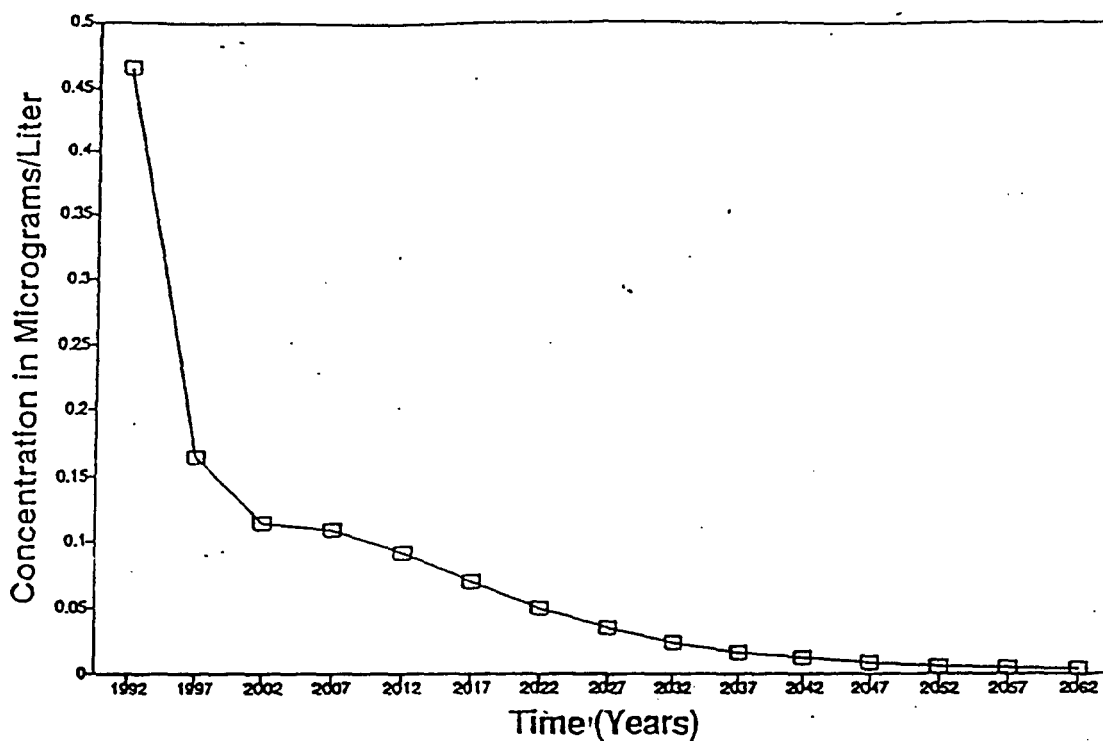
Figure 11

Project
No. 8820072

Fort Lewis
Landfill No. 5

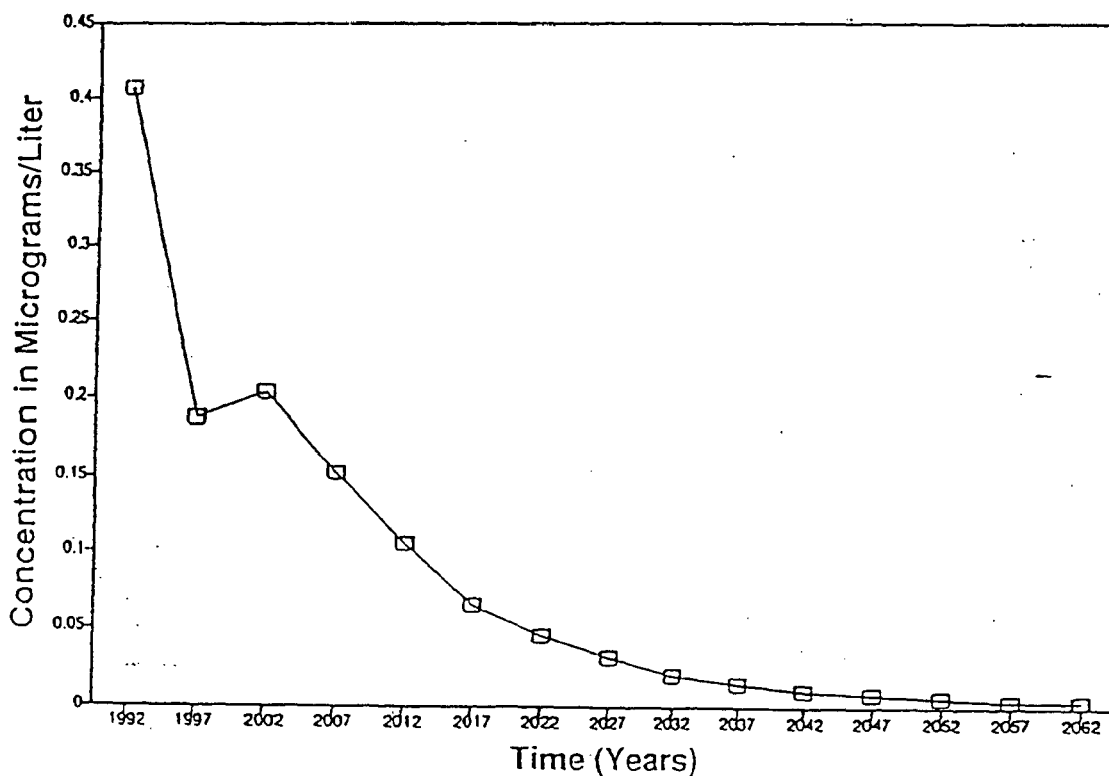
Woodward-Clyde Consultants





**MODELED CONCENTRATIONS: Trichloroethene Arrival Patterns
at Well 88-LS-AX-VD**

Figure 12



**MODELED CONCENTRATIONS:
1,2 Dichloroethane Arrival Patterns
at Well 88-LS-AX-VD**

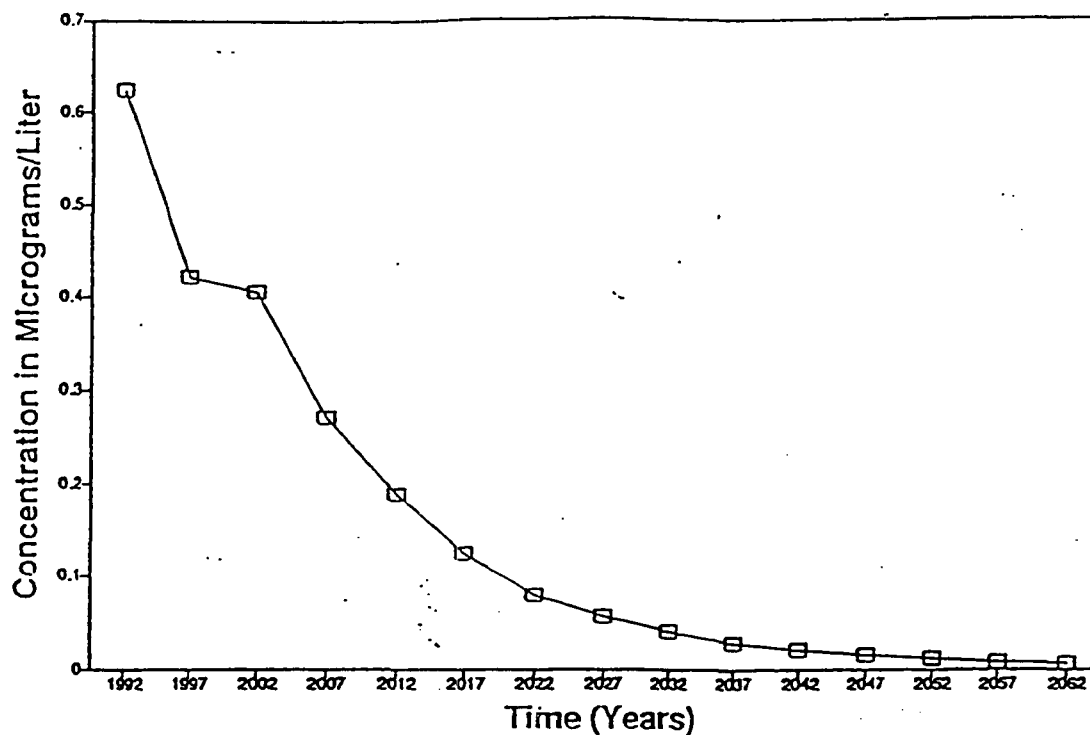
Figure 13

Project
No. 8820072

Fort Lewis
Landfill No. 5

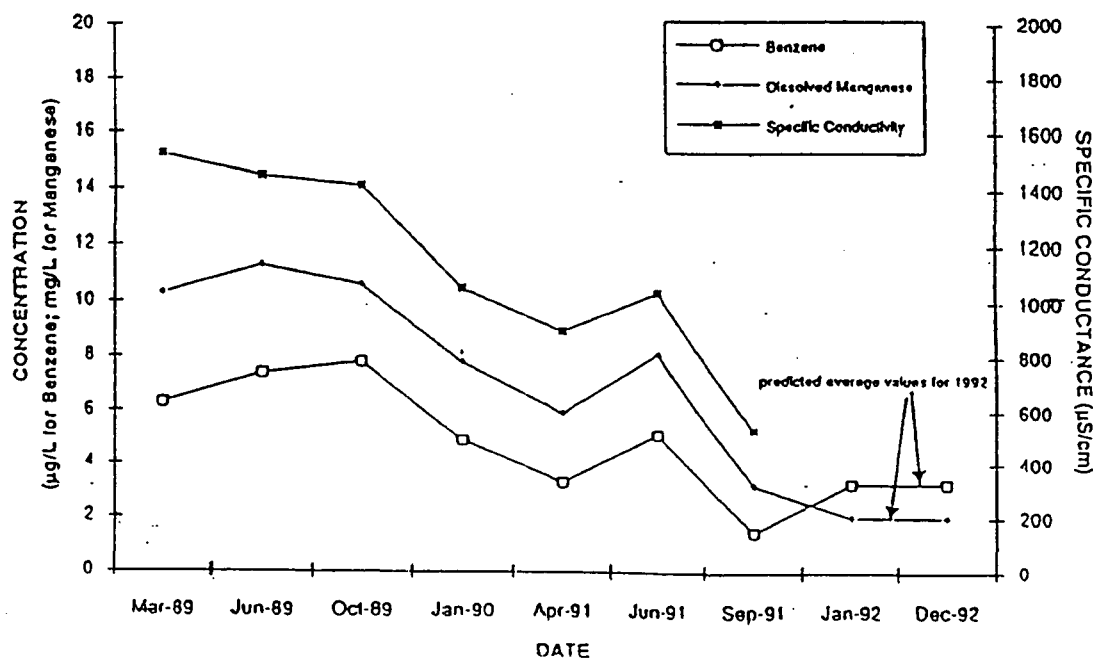
Woodward-Clyde Consultants





**MODELED CONCENTRATIONS: Vinyl Chloride Arrival Patterns
at Well 88-LS-AX-VD**

Figure 14



Project
No. 8820072

Fort Lewis
Landfill No. 5

Groundwater Measurements for Benzene,
Dissolved Manganese, and Specific
Conductance for MW 88-LS-AM-VD
Fort Lewis Landfill No. 5

Figure 15

Woodward-Clyde Consultants



U.S. Army

FORT LEWIS LANDFILL NO. 5

Public Meeting
March 3, 1992

COMMENT SHEET

Please use this form to make comments about the Proposed Plan for Fort Lewis Landfill No. 5. You may return this sheet (and/or additional sheets) to a study team member at this evening's meeting, or take it with you to fill out later. Your comments may be addressed to: I Corps and Fort Lewis, Attn: AFZH-DEQ (Paula Wofford), Fort Lewis, WA 98433-5000. Comments must be received by March 9 to be considered in finalizing the Proposed Plan. Thank you for your interest and comments.

Name: (b) (6) Phone: (b) (6)
Organization: (b) (6)
Mailing Address: (b) (6)
City: (b) (6) State: WA Zip: (b) (6)

COMMENTS: re: p. 2 proposed plan - If Landfill # 5 not a source of sediment contamination, what is the source?

Why were the levels of Benzene and Dissolved Mn/Manganese up in Jan 91 if the landfill was already covered?

If investigative results showed no change in Vinyl Chloride & 1,2 dichloroethane between Oct 89 and Sept 91 how can the model show the 30-year Avg down?

Is landfill maintenance going to be the same as all other facility maintenance at HHS during?

MAR-13-'92 16:20 ID:

DEH

TEL NO:206 964 3289

4435 P03

VI-

Postmarked 10 Mar,
will include in Responsiveness
Summary but will note
that it was a day late.

CITY OF DUPONT

Post Office Box 455
Dupont, Washington 98327
(206) 964-8121 • FAX 964-8554

March 9, 1992

HQ I Corps and Fort Lewis
ATTN: AFZH-DEQ (Paula Wofford)
Fort Lewis, WA 98433-5000

SUBJECT: REVIEW OF ARMY'S PROPOSAL FOR NO FURTHER ACTION FOR
FORT LEWIS LANDFILL NO. 5

Dear Ms. Wofford:

Based on our review of the summary proposed plan for Landfill No. 5, we had a number of questions. Our engineer visited your office March 6, 1992 to examine the administrative record for the site. We were able to clarify numerous issues through this visit, but have several remaining questions. The answers may be present in the administrative record, but there is more material than could be reviewed in detail in the several hours we had allowed. We would appreciate your responses to the following:

1. What is the manufacturer's suggested working life for the high density polyethylene used in capping the East-West landfill zones when the material is used in this type of application? Are there any plans to check liner integrity periodically?
2. We have several questions regarding the monitoring to be performed as part of the landfill closure:

How frequently will samples be collected as part of the on-going site monitoring? What tests will be performed?

For how many years will the monitoring continue?

Where will the samples be collected? Will the sample sites include both cross-gradient and up-gradient sites as well as the plume areas portrayed in the documentation of the remedial investigation? We would particularly like to see regular monitoring of groundwater in the region between the landfill and the City of DuPont's Bell Hill well site.

Will both surface water and groundwater be sampled?

Will there be additional checks of future monitoring results

Page Two.

against computer model predictions to either verify model accuracy or point to the need for additional study?

Where and how will the monitoring results be reported? Will the results be available to the public?

Describe how additional action could be triggered by the water quality monitoring results. Are specific groundwater contaminant concentrations the only activating mechanism, or are there a variety of explicit warning signs established to automatically prompt increased activity? What types of additional action might be required in case of a further deterioration in water quality?

3. Are there any provisions for on-going monitoring of groundwater level within the landfill or in the immediate vicinity? This might allow early detection of any significant additional groundwater intrusion or progressive changes in water table level which could lead to additional pulses of leachate entering the groundwater.
4. What is the status and are there any current results from the separate study of waste disposal practices in the vicinity of the drainage channel, cited in the summary of the proposed plan?
5. What efforts are being made today to sort and monitor the waste stream entering the landfill? Compare current recordkeeping practices to historical practice, as summarized in the documentation of the remedial investigation.

Thank you for the opportunity to review the plans for Landfill No. 5 and also for your attention to our questions.

Sincerely,

CITY OF DUPONT


WILLIAM H. GORGENSEN
Mayor

WHG/clo

12 MAR 1992
11:11 AM
11:11 AM